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**To Support Research Activities Under the NASA Experimental
Program to Stimulate Competitive Research**

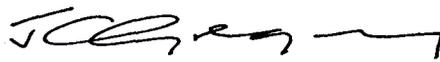
**(NASA EPSCoR Continuation Grant)
NCC5-165**

**FINAL REPORT
(June 1, 1997 – August 31, 2001
extended through April, 2002)**

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**NASA EPSCoR Continuation Grant
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FINAL REPORT**

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ALABAMA NASA-EPSCoR FINAL REPORT

I. INTRODUCTION

The Alabama NASA EPSCoR Program is a collaborative venture of The Alabama Space Grant Consortium, The Alabama EPSCoR, and faculty and staff at 10 Alabama colleges and universities as well as the Alabama School of Math and Science in Mobile. There are two Research Clusters which include infrastructure-building and outreach elements embedded in their research activities. Each of the two Research Clusters is in an area of clear and demonstrable relevance to NASA's mission, to components of other Alabama EPSCoR projects, and to the State of Alabama's economic development.

This Final Report summarizes and reports upon those additional activities occurring after the first report was submitted in March 2000 (included here as Appendix C) as a continuation of NCC5-165. Since the nature of the activities and the manner in which they relate to one another differ by cluster, these clusters function independently and are summarized in parallel in this report. They do share a common administration by the Alabama Space Grant Consortium (ASGC) and by this means, good ideas from each group were communicated to the other, as appropriate

During the past year these research teams, involving 15 scientists, 16 graduate students, 16 undergraduates, and 7 high school students involving 10 Alabama universities had 14 peer reviewed scientific journal articles published, 21 others reviewed for publication or published in proceedings, gave 7 formal presentations and numerous informal presentations to well over 3000 people, received 3 patents and were awarded 14 research proposals for more than \$213K dollars in additional research related to these investigations. Each cluster's activities are described below and an Appendix summarizes these achievements.

II. THE ADVANCED MATERIALS DEVELOPMENT RESEARCH CLUSTER

Materials research is a major component to all of the Alabama EPSCoR programs. The objective of this research program is to investigate means by which materials performance may be enhanced through engineered interface and surface modification. This Research Cluster builds on existing strengths and extends the research effort into other areas and expands the statewide effort to other institutions. The efforts of this Research Cluster in the final year were focused on development of new diamond cubic boron nitride, and other materials for high performance coatings needed both in space and in manufacturing industrial applications.

In this past year, particular progress has been made in the refinement of techniques for developing, analyzing, and improving the quality of nanocrystalline coatings and films and other structures. The research programs have provided both graduate and undergraduate students with opportunities in their college careers to investigate and practice some general principles of materials science to solve real-world problems related to the process of design for manufacturability, tool selection, and tool path optimization.

This Cluster included a total of seven universities and was led by the University of South Alabama and UAH after Dr. Komar moved to Florida. It involved four other Space Grant Universities (Auburn (AU), Alabama (UA), Alabama at Birmingham (UAB), and Alabama in Huntsville (UAH)) and three smaller Alabama institutions (the Alabama School of Math and Science (ASMS), one historically black college (Oakwood College(OC)), and Samford University (SU)). The smaller institutions provided undergraduate research assistants that became involved in the research project carried out at the larger university enabling them to do research not previously available to them.

In addition, the projects themselves relate to one another so that the output or product of one project becomes one of the inputs or materials to be tested in another; thus, an extrinsic collaborative network was formed among faculty, students and the various institutions involved. In this way faculty and students linkages have been continued among the cluster institutions in the seventh year. These represent a major enhancement of Alabama's research/educational infrastructure, particularly in the opportunities they provide for faculty and students at smaller institutions.

Collaboration also extends to two research groups in other universities (beyond the cluster) to four groups in government laboratories, and to one industry group. In this seventh year, this cluster had 8 papers at various stages of the publication cycle, 3 theses or dissertations completed, 4 papers presented at national or international meetings, 3 patents awarded or pending and has submitted proposals totaling \$336K of which \$189K had been awarded. Among the most notable achievements this past year in the Advanced Materials Group, UAB physicist Yogesh Vohra and a former graduate student, Dr. Shane Catledge, were allowed a patent entitled "A Process for Ultra Smooth Diamond Coating on Metal and Uses Thereof" with applications ranging from machine tools to heart valves and hip implants.

The Advanced Materials Development Research Cluster includes the following individuals, institutions and projects:

Project #	Coordinators	Institution	Project Title
1	A. Kumar, PhD G.Wattuhewa, PhD	USA ASMS	Laser Processed Surface Modification, Coating and Thin Films
2	Y. Tzeng, Ph.D.	AU	Novel Process & Applications of CVD Diamond, Cubic Boron Nitride, and High Tc Superconductors
3	V. Acoff, PhD J. Luo, Grad Stud	UA	Microstructure & Mechanical Properties of Microlaminates
4	Y. Vohra, PhD J. Tarvin, PhD	UAB SU	Microwave Plasma Processing & Gas Phase Diagnostics for Diamond Coating of Curved Surfaces of Aerospace Materials
5	M. George, PhD	UAH	Surface & Optical Characterization of Thin Films & Coatings
6	A. Kumar, PhD	USA	Simulation & Numerical Analysis in Support of Materials Processing

III. INDIVIDUAL RESEARCH PROJECTS FOR ADVANCED MATERIALS CLUSTER

Advanced Materials Cluster Evolution of Research Goals

The Advanced Materials Cluster identified the following potential foci for studies under the NASA EPSCoR:

1. Nanoscale measurement and manipulations. These include new and established methodologies such as atomic force microscopy.
2. Growth and characterization of nanostructured materials including nanocrystalline films and structures composed of single and/or arrayed molecules.
3. Growth and characterization of single walled carbon nanotubes.
4. the development and engineering of microelectromechanical devices (MEMS) for sensor applications
5. Molecular electronics for device and sensor applications.
6. Nanobiology for applications such as biosensors.

In an effort to initiate active research programs in these areas, many of the PI's tailored their research efforts towards these foci. The following are brief descriptions of each research project.

Project 1: Laser Processed Surface Modification, Coating and Thin Films (Coordinators: Dr. A. Kumar, University of South Alabama and Dr. G. Wattuhewa, Alabama School of Mathematics and Science

Nanocrystalline materials have been attracting rapidly increasing interest in the last decade and have the potential of revolutionizing traditional materials design in many applications via atomic-level structural control to tailor the engineering properties. The technical objectives achieved in this project can be enumerated as follows; 1. Pulsed laser deposition of PLD of nanocrystalline TiN/Si₃N₄ composite coatings on silicon substrates, 2. Characterization of microstructure and composition, and 3. Evaluation of surface hardness and tribological properties.

USA researchers and facilities were joined by four Alabama School of Mathematics and Science students in this research. They were directly involved in preparing thin film samples, analyzing data, surface characterization and learning high vacuum techniques. They also worked with graduate students to learn the operation of SEM and XRD. Systematic studies were then completed on the hardness and elastic modulus of the nanostructured diamond films produced by this method. Nanostructured films were synthesized by adding varying amounts of nitrogen to methane/hydrogen plasma. Further investigations studied the variation of these qualities as a function of depth and new instrumentation allowed scattered light intensity measurements from the surface of the substrate in the microwave plasma chemical vapor deposition system. A computer model was then developed to evaluate the diamond particle size by monitoring the scattered light. This study has provided critical information about the nucleation phase (diamond particle size as a function of time) in the case of nanostructured diamond coatings grown under different conditions.

Project 2: Novel Processes and Applications of CVD Diamond, Cubic Boron Nitride, and High-Tc Superconductors: High Density Carbon Nanotube Growth and Coatings (Coordinator: Dr. Yonhua Tzeng, Auburn University)

Coating of large-area diamond films and production of high-quality free-standing diamond plates are very desirable for uses in both NASA missions and industrial applications. Before this excellent diamond material becomes commercially useful, the production costs and the quality of diamond films must be improved. The goals of this project include the exploration of high-density microwave plasmas and hot filament CVD techniques for low-cost manufacturing of diamond films. In contrast to most diamond CVD processes, no compressed gases will be used as the precursors for diamond deposition. By the proper mixing of methanol with other liquid compounds, the solution is fed into a chemical vapor deposition chamber through a needle valve without the use of electronic mass flow controllers. This process has a potential of becoming the standard diamond CVD process for mass production of diamond films because they are safer and cheaper than other processes that are currently being used.

Research and development carried out during the NASA EPSCoR program has led to four important inventions: methanol-based microwave plasma enhanced diamond chemical vapor deposition, methanol-based hot-filament assisted diamond chemical vapor deposition, electron assisted RF sputtering of cubic boron nitride, and rapid smoothing and shaping of diamond. In 2002, the liquid source diamond CVD project was further investigated to optimize the process parameters and to widen the practical applications of the CVD process. Emphasis was placed on nano-structured materials and devices based on carbon nanotubes.

Sponsorship from EPSCoR supported the Sixth Applied Diamond Conference/Second Frontier Carbon Technology Joint Conference held at Auburn University on August 6 – 10 2001. Two hundred thirty-eight (238) scientists, technologists and students representing over 10 countries were in attendance. The conference proceedings were published by NASA Glenn Research Center, report number NASA CP-2001-210948. Alabama participation included 22 students (total student participation was 49) and 7 faculty members.

Project 3: Microstructure and Mechanical Properties of Microlaminates (Coordinator: Dr. Viola L. Acoff, University of Alabama)

This project supported the work of Mr. Jian-Guo Luo, a PhD student in the Department of Metallurgical and Materials Engineering. Mr Luo's work focused on the development of a novel processing method for producing microlaminates. Mr. Luo has been successful in developing the processing sequence and identifying the reaction sequences to achieve a complete reaction between elemental foils of titanium and aluminum to produce microlaminates from the intermetallic compound TiAl. Mr. Luo completed his thesis on this subject in August 2001 and published a paper in 2000.

Having used this multi-pack rolling technique to produce ultra-fine grained sheets, researchers then performed feasibility studies for incorporating the development of nanotechnology. Further modification of the existing process has allowed for multi-pack roll bonding to be used with

diffusion annealing producing nanostructured materials. The titanium-aluminum system was used as the model for the feasibility study.

Project 4: Microwave Plasma Processing and Gas Phase Diagnostics for Diamond Coating of Curved Surfaces of Aerospace Materials (Coordinator: Yogesh Vohra, Department of Physics, University of Alabama at Birmingham with Dr. John T. Tarvin, Samford University)

This project involved two areas of research: multi-layer nanocrystalline diamond films and diamond coating on cylindrical Ti-6Al-4V alloy rods. In the first area, a new approach for synthesis of a graded diamond layer on a titanium alloy substrate was investigated. The purpose of this graded three-step approach was to have a tough nanocrystalline film at the interface, followed by a hard microcrystalline layer, and then back to a nanocrystalline layer as the outermost layer. The outermost layer is needed to have a low coefficient of friction for various applications, which require movement of the coated specimen against another surface. The Laser reflectance interferometry (LRI) was used as an insitu diagnostic tool to monitor the growth rate and surface roughness for a diamond film grown using a three step chemical vapor deposition (CVD) process in which a multi-layer (nanocrystalline/ microcrystalline) structure was produced. This multi-layer structure was achieved by regulating the concentration of N_2 in H_2/CH_4 microwave plasma.

In the second area of research, there are two main challenges in the coating of curved surfaces, one is to achieve uniform plasma density on the curved surface and the other is to avoid separation of diamond film due to thermal stress. In one experiment, a preliminary attempt to coat a cylindrical rod of titanium alloy 8 mm in diameter and length was made. The deposition was carried out in Methane/Hydrogen/Nitrogen plasma using 6 kW microwave plasma chemical vapor deposition system at an average rod temperature of 800 degrees C. This experiment was a partial success as part of the diamond film separated on cooling from the top of the cylinder. New ideas were tried to improve the heat sinking of this object and reduce temperature gradients and thermal stresses during the cool down period from the deposition temperature. Thin film x-ray diffraction on this cylindrical rod confirmed the presence of diamond in the surface layer.

Three faculty members, one graduate students and one undergraduate student worked on this project resulting in obtaining one patent and publication of two peer-reviewed articles.

Project 5: Surface and Optical Characterization of Thin Films and Coatings (Coordinator: Michael A. George, University of Alabama at Huntsville)

Three areas of interest were investigated: characterization of pulsed-laser deposited films(PLD), MEM's and nanotechnology research and the characterization of advanced materials by scanning probe microscopy. This included the study of zinc oxide prepared by sputter and pulsed laser deposition methods, studies on carbon nanotubes grown by pulsed laser deposition methods, studies on carbon nanotubes grown by pulsed laser methods and some initial studies grown by reverse micelle processes.

In the characterization of PLD, Dr. Kumar submitted one paper and made two conference presentations. Because of the move of PI Kumar to Florida, new collaborations were established with other researchers. Dr. George collaborated with Dr. Wattuweha (Alabama School of Math and Science) to investigate thin film coatings on microcantilever sensor surfaces for enhanced sensitivity and with Dr. Joseph Ng (UAH) in the development of microcantilever-based biosensors for t-RNA-Protein recognition.

In the MEM's and Nanotechnology research, the following progress was made:

- * A NASA funded program involving collaboration with investigators at Alabama A & M University, the NASA Glen Research Center and UAH received additional funding to focus on developing a stable elevated temperature silicon carbide sensor.
- * Collaboration with MEM's Optical, a local private company in Huntsville, was established. This work involves the study of surface forces that may have applications in nanostructured devices and was supported by a university-industry pilot grant.
- * Work continued on the development of research on microcantilever sensors. This is an effort involving UAH scientists, the Oak Ridge National Laboratory and a group at the Naval Research Labs resulting in proposal generation.
- * Initiation of feasibility studies to synthesize and characterize single walled carbon nanotubes in collaboration with MSFC.

The work on zinc oxide films resulted in four publications and two conference presentations in 2000. A paper on the study of zeolites was also produced.

Project 6: Simulation and Numerical Analysis in Support of materials processing (Coordinator: Dr. Ashok Kumar, University of South Alabama) Note: Dr. Kumar's work results were reported above. This section briefly described his contribution to the cluster's activities.

Laser-induced desorption and ablation result from the conversion of an initial electronic or vibrational photoexcitation into kinetic energy of nuclear motion, leading to the ejection of atoms, ions, molecules, and even clusters from a surface. In laser ablation process, design of processing experiment requires consideration of the coupling of the laser energy with target via the optical delivery system. There are several ablative mechanisms by which material, either atomic or bulk, can be released from the surface of the target. A computational model has been developed in order to simulate heat transfer with phase transition in laser ablation with or without the kinetics consideration. The front fixing method with Landau transformation has been used to report the geometric domain. Energy absorption, heat transfer (1-D heat conduction), melting model, and surface vaporization have been modeled to understand the ablation mechanism for simple systems. The spectral collection method has been used for special discretization in this model, while backward differentiation techniques have been used for temporal discretization. A one-dimensional model has been compared with the experimental results, but more work is needed to establish the 3-D model for multifunctional applications.

IV. THE REMOTE SENSING CLUSTER FOR HYDROLOGICAL MODEL DEVELOPMENT

The Alabama NASA EPSCoR Remote Sensing Cluster reported significant results in research, outreach/extension education during the period of June 2000 till May 2001. The Remote Sensing Cluster research tasks are much more interdependent than those of the Advanced Materials Cluster and in this sense, require significantly more group interaction in the planning, training, and decision-making activities.

This Research Cluster was led by Auburn University (AU), and includes lead coordinators from Jacksonville State University (JSU), and Alabama A & M (AA&M). From these institutions, 8 scientists, 16 undergraduates, and 8 graduates students were directly involved in the cluster research and education. Twelve grant proposals were submitted, of which 7 were funded in the amount of \$83K with 6 peer-reviewed publications resulting. Collaborations with the USDA-ARS National Soil Dynamics Laboratory, the Global Hydrology and Climate Center of the NASA Marshall Space Flight Center, and the Alabama Cooperative Extension System were an integral part of the program.

The backbone of the activities of this Research Cluster in the past year was the use of high spatial resolution thermal infrared remote (TIR) sensing for site-specific agriculture (SSA). In past years, a strong correlation between spatial variations in thermal infrared emission was measured from fields several months before harvest and yield maps obtained at harvest. This year the research centered on soils in a double effort to understand crop yield variability in terms of soil properties and to determine the ability of thermal infrared combined with visible and near IR remote sensing to measure some soil properties like soil organic content. Ground truthing and evaluation of the nitrogen status of corn crops was also elevated in the research for this year.

Project #	Coordinators	Institution	Project Title
1	T. Tsegaye, PhD	AA&MU	Spatial Distribution of Near Surface Temperature and Soil Moisture under Bare and Vegetated Plots
2	S.H. Al-Hamdani, Ph.D.	JSU	Precision Farming in Northern Alabama
3	J.M. Wersinger, PhD, J.N. Shaw, PhD, and P.L. Mask, PhD	AU	Using Remote Sensing to Further Precision Farming in Alabama

V. THE REMOTE SENSING CLUSTER PROJECTS ACTIVITIES

All agricultural research activities were coordinated and overseen by Auburn University and Dr. Shaw. Four sites were used for collecting the data: Glenn farm in Lawrence county, the Jacksonville site in Hazel Green at the Winfred Thomas Agricultural Research Station, Sand Mountain substation of the Agricultural Experiment Station near Crossville, and the Wiregrass substation of the Agricultural Experiment Station near Headland – all in North Alabama.

Project 1: Spatial Distribution of Near Surface Temperature and Soil Moisture under Bare and Vegetated Plots (Coordinator: T. Tsegaye, AA&M)

The more important factor affecting the ability of plants to evaporate water and remain turgid is the amount of plant available water in the soil. This evaluating soil moisture was essential to this study although the study area was restricted mostly to north Alabama. The spatial distribution of near surface soil moisture contents was determined following the methodology devised by Tsegaye by combining both gravimetric and Time Domain Reflectometry (TDR) methods. These measurements were then compared to remotely sensed data to examine the validity of using remote sensing techniques to predict availability of water to plant growth. An independent estimate of plant water content was obtained with an active remote sensing approach that used a Synthetic Aperture Radar (SAR). This was made possible through collaboration with Utah State University and Rocky Mountain Space Grant.

Project 2: Precision Farming in Northern Alabama (Coordinator: S.H. Al-Hamdani, JSU)

Groundwork on crops has been done on the Jacksonville farm and Decatur site measuring plant health and yield. Fundamental aspects of solar energy interactions with plants were the focus of this research component. The crops studied were corn, cotton and soybean. A Licor (1800) was used to determine absorption, reflectance, and transmission of light intensities for each type of crop during critical stages of seeding development, flowering, and fruiting. Other physical and processual data were measured. Results were compared to yields and to the RS images obtained from Atlas.

Project 3: Using Remote Sensing to Further Precision Farming in Alabama (Coordinator: J. M. Wersinger, J.N. Shaw, and P.L. Mask)

Successful activities have been conducted in outreach and education and were headed up in Auburn. Drs. Rickman and Mask have been effective in giving high visibility talks. Following a news release from MSFC, Dr. Rickman was interviewed by local news media. Several papers and TV stations covered the story. The web site "space.com" ran a long article on precision farming research which was nominated for a Discovery Award. Dr. Mask coordinated a visit to Glenn farm for several groups one of which included the CEO of ALFA Insurance Company, as well as several Congressional aides. He made numerous presentations about the effort at professional meetings and estimates having reached about 3,000 people from commodity groups, farmers' associations, extension people, commercial agricultural companies and researchers.

Results of previous work done in collaboration with the Georgia group (UGA and NESPAL) and funded by the Alabama and Georgia Space Grant Consortia were showcased at the National Remote Sensing Applications Conference and Workshop that took place in Auburn in November 1999. One hundred twenty participants were in attendance.

The three universities involved have curricula in geospatial information technologies. Efforts have been made to learn from each other and share as curricula was developed. One meeting for this purpose was held and included NASA scientists. An Introductory Remote Sensing undergraduate course was developed and offered twice at Auburn University. It includes a lab

developed by a graduate student, Ms. Ruslana Svidzinska and has been revised after the first session.

Ms. Svidzinska continued to work on the so-called “wind-effect” that appeared on some of the images produced from the thermal infrared bands data. She systematically examined all RS images obtained by the Atlas sensor to estimate the prevalence of the “wind effect” characteristics. This task involved review of approximately 12 GB of data. The final aspect of this research was designed to determine if the thermal wind effect can be correlated with soil, plant or with atmospheric phenomenon since understanding the wind effect is important to interpreting the correlations found with the yield.

Economics is a determining factor for the potential adoption of remote sensing for precision agriculture by farmers. A foray into these aspects was undertaken by Dr. Upton Hatch , agricultural economist at Auburn University. His detailed cost and returns analysis of the use of alternative variable rate technologies provided insight into the future viability of the technology in question. A case study of farmers cooperating with the project was completed. Interviews indicate that farmers have a high interest in understanding the economics of implementation and the use of remotely sensed data as well as a strong willingness to share data and information.

Auburn also coordinated with the NASA MSFC staff to develop a website entitled, “Alabama from Space” featuring bi-weekly biomass landcover images and a greenness index. The website will also make use of existing archived satellite images of Alabama to show changes in land use since the early 1970s. .

Finally, researchers in Auburn’s School of Forestry and Wildlife Sciences took advantage of the opportunity to investigate the ability of ALTAS sensor to discriminate species and structural attributes of silviculturally managed and unmanaged forests in Alabama. Three sites, two coastal plain longleaf pine restoration sites and one rare montane longleaf pine site were included in the flight data. This data was useful in the discrimination of various structural attributes and has led to an enhanced understanding of silvicultural management and restoration.

APPENDIX A
PUBLICATIONS, PRESENTATIONS, GRANTS AND PATENTS:
ADVANCED MATERIALS CLUSTER

A. PUBLICATIONS

Baker, Paul A., Shane A. Catledge, "Low Temperature Growth of Nanostructured Diamond Films", *Journal of Nanoscience and Nanotechnology*, Volume 1, No. 1, (March, 2001).

Catledge, Shane A., Paul A. Baker, John T. Tarvin, and Yogesh K. Vohra, "Multi-layer Nanocrystalline/Microcrystalline Diamond Films Studied by Laser Reflectance Interferometry", *Diamond and Related Materials*, 9, 1512 (2000)

Lou, J.G., and V.L. Acoff, "Interfacial Reactions of Titanium and Aluminum during Diffusion Welding", *Welding Journal*, Vol. 79(9), 239-243s, (2000)

Shen Zhu, C.-H. Su, S. L. Lehoczky, M. T. Harris, M. J. Callahan, P. McCarty and M. A. George, "Substrate Preparations in Epitaxial ZnO film Growth", Accepted by *J. Crystal Growth* (2000).

Shen Zhu, C-H Su, S. L. Lehoczky, and M. A. George, "Polarity Effects of Substrate Surface in Epitaxial ZnO Film Growth", *Journal. of Crystal. Growth*, 219, 361 (2000).

Shen Zhu, C-H Su, S. L. Lehoczky, P. Peters, M. A. George, and P. M. McCare, "Morphology, Structure, and Conductivity of ZnO Films Grown by Off-Axis Sputtering Deposition", *Journal of Materials. Research*, 15, 1125 (2000).

Shen Zhu, C-H Su, S. L. Lehoczky, P. Peters, and M. A. George, "Pressure Effects in ZnO Films Using Off-Axis Sputtering Deposition", *Journal. of Crystal Growth*, 211, 106 (2000).

B. CONFERENCE PAPERS ACCEPTED FOR PUBLICATION/OTHER PUBLICATIONS

P. Dutta, M.A. George and S. Laurent, "Study of Zinco-Phosphate Zeolites prepared by the Reverse Micelle Method". (under preparation)

Y. Tzeng, C. Liu and Z. Chen, "Electron Emission from Microwave Plasma CVD Carbon Nanotubes", *Mat. Res. Soc. Symp. Proc.* Vol 621.R7.3.1- R73.6, accepted for publication.

Y. Tzeng, C. Liu and Z. Chen, "Hot Filament Assisted Fabrication of Carbon Nanotube Electron Emitters", *Mat. Res. Soc. Sym. Proc.* Vol 261 R7.5.1 -R7.5.7, accepted for publication.

Z. Chen, Y. Tzeng, C. Liu and C. Cutshaw, "Fabrication and Applications of Microstructured Ni-C Electrodes with High-Density Carbon-Nanotube Coatings", *Mat. Res. Soc. Sym. Proc.* Vol. 621.R7.4.1 – R7.4.4, accepted for publication.

C. Liu, Y. Tzeng, and C. Cutshaw, "Brazen CNT Electron Emitters," submitted to ADC/FCT 2001 held Aug 2001 at Auburn University

C. Liu, Y. Tzeng, and C. Cutshaw, "Carbon Coatings on glass Plates as Electron Emitters", submitted to ADC/FCT 2001 held at AU

C. PRESENTATIONS

C. Baron, D. Wheeler, G. Wattuhewa, "Instrument for Measuring Temperature and Salinity", NCSSSMST Student Res. Sym. For Secondary Schools, University of Miami, Coral Gables, Florida, June 7-10, 2001

J. Murray and G. Wattuhewa, "Thin Film Coating Using Pulsed Laser Deposition" NCSSSMST Student Res Symp. For Secondary Schools, University of Miami, Coral Gables, Florida, June 7-10, 2001).

S. Zhu, C-H Su, S. L. Lehoczky, and M. A. George, "Study of Doped ZnO Films Synthesized by Combining Vapor Gases and Pulsed Laser Deposition", 7th IUMRS - ICEM "International Conference on Electronic Materials" in Symposium D - Photon-induced Material Processing, at Strasbourg, France, May 30 – June 2, 2000.

S. Zhu, C-H Su, S. L. Lehoczky, M. T. Harris, M. J. Callahan, and M. A. George, "Substrate Preparations in Epitaxial ZnO film Growth", Twelfth American Conference on Crystal Growth and Epitaxy, August 13-18, 2000, Vail, Colorado.

D. PATENTS

Y. Tzeng and H.B. Zhu, "Method of Synthesizing Cubic Boron Nitride Films", U.S. Patent Number 6,153,061, (November 28, 2000)

Y.K. Vohra and S.A. Catledge, "Process for Ultra Smooth Diamond Coating on Metals and Uses Thereof", U.S. Patent Number 6,183,818, (February 6, 2001)

C. Zheng, and Y. Tzeng, "Structures with High Number Density of Carbon Nanotubes and 3-Dimensional Distributions", US Patent filed September, 2000

E. GRANTS AND PROPOSALS **NEW GRANT VALUE**

Thirteen grants were submitted during the EPSCoR period of research. Seven grants were awarded totaling \$135,000 and another 5 were pending with a cumulative total project value in excess of \$2 million. One was not funded: "Development of Microcantilever Sensors". DOD for \$500,815

GRANTS AWARDED

- \$59,914 "Study of Surface Forces on MEMs Devices" MEMS Optical LLC., Huntsville, Alabama. 8/1/01-7/31/02
- \$50,000 "Study of Structure, Composition & Electrical Properties of Silicon Carbide Epitaxial Films." NASA Grant Number NAG3-2285. 7/99-6/02
- \$45,000 "Development of Materials for Applications in Nanotechnology." NASA EPSCoR Grant Number NCC5-165. 5/00-2/02
- \$12,000 "AFM Characterization of Crystals Grown in Microgravity." NASA; Grant Number N3537-1. 12/00-11/01
- \$28,000 "Study of Quantum Vacuum Energy from Surfaces in MEMS Devices." NASA Grant Number NGT5-40018 Alabama Space Grant; and MEMS Optical LLC. 2/1/00-1/31/01
- \$22,000 "Growth and Characterization of Ordered Carbon Nanotubes for Imaging and Array Applications." Alabama Space Grant. 8/00-5/01.
- \$17,192 "Study of properties of Biodegradable Polymers as Coatings For Biological and Biomedical Applications." University of Alabama Contract 00-035. 8/00-5/01.

GRANTS PENDING

- \$57,900 "Study of the Crystal Growth of Microporus Material by Atomic Force Microscopy." NASA. Submitted 4/01. 2 years
- \$1,441,384 "Directed Assembly of Complex Nanoscale Materials using DNA Templates." DOE. Submitted 3/01. 3 years
- \$570, 834 "Study of Microcantilever Sensor Properties." NSF Proposal 2000-138. Submitted 1/01. 3 years
- \$1,076,496 "Crystallization and crystallographic studies of tRNAs from *Escherichia coli* and *Thermotoga maritime*." NASA. Submitted 10/00. 4 years

F. STUDENTS SUPPORTED/PARTICIPANTS

UNDERGRADUATES

Seven undergraduates were directly involved in the research undertaken by this cluster and 48 students from around the world participated in the conference held on Diamond and Carbon Technology sponsored by this grant.

GRADUATES

Four Graduate students were supported in the completion of masters or doctoral theses in the course of this research. Four additional graduate students worked directly on the projects with supervision from coordinators and other faculty participants.

P. Baker, (Dept. of Physics, UAB PhD candidate)

S. Catledge (Dept. of Physics, UAB PhD completed)

J.G. Luo, "Processing Near Gamma-Based TiAl by Cold Roll Bonding and Diffusion Reaction of Elemental Titanium and Aluminum Foils", PhD dissertation awarded August 2001, UA

C. Liu, awarded M.S. in EE, Auburn University, Summer, 2000

FACULTY

Seven faculty members participated including the coordinators listed for each project.

G. COLLABORATIONS WITH NASA CENTERS, INDUSTRY AND OTHERS

NASA Center: Prof. Tzeng, Auburn University collaborated with Dr. K. Miyoshi of NASA Glenn Research Center to organize the Sixth Applied Diamond Conference/ Second Frontier Carbon Technology Joint Conference held in Auburn University in August 2001. Two hundred forty participants submitted over 200 presentations representing 22 countries from around the world

University: Prabir Dutta, Ohio State University, Characterization of zeolite materials; Daryush Ila, Alabama A&M University, study of silicon carbide;

Industry: MEMS Optical, Characterization and Quantum Fields LLC., characterization of surface forces on MEMS Devices

Government Labs: Shen Zu, AFM Characterization of ZnO Crystals; S. Laurent, Characterization of micro porous materials; D. Larkin, NASA Glenn Research Center, SiC Sensors; T. Thundat, Oak Ridge National Labs, Development of Microcantilever Sensors;

APPENDIX B
PUBLICATIONS, PRESENTATIONS, GRANTS AND PATENTS:
REMOTE SENSING CLUSTER

A. PUBLICATIONS

Al-Hamdani, S.H., P.B. Nichols and G.R. Cline. 2002. Seasonal Changes in the Spectral Properties of Mountain Laurel (*Kalmia latifolia* L., *Ericaceae*) in North East Alabama. *In* *Castanea* 67(1): 25 – 32.

Al-Hamdani, S.H. 2002. Remote Sensing as a Tool for Plant Stress Identification. *In* *Crop Science Journal*, in press.

Sullivan, D.G., J.N. Shaw, P.L. Mask, D. Rickman, J. Luvall, J.M. Wersinger, and E.A. Guertal. 2003. Rapid assessment of in situ wheat straw residue via remote sensing platforms. *Soil Sci. Soc. Am. J. In Review*.

Sullivan, D.G, J.N. Shaw, D. Rickman, P.L. Mask, J.M. Wersinger, and J. Luvall. 2003. Using remote sensing platforms to estimate near-surface soil properties. *Remote Sens. Environ. In Review*

Sullivan, D.G, J.N. Shaw, P.L. Mask, D.L. Rickman, J. Luvall, and J.M. Wersinger. Evaluating Corn (*Zea Mays* L.) N Variability Via Remote Sensed Data. *Commun. Soil Sci. Plant Anal. In Review*

Thompson, A.N., J.N. Shaw, P.L. Mask, J.T. Touchton and D. Rickman. Soil sampling techniques for Alabama grain fields. *Prec. Ag. In Review*

B. PRESENTATIONS – PUBLISHED PROCEEDINGS AND ABSTRACTS AND MEDIA COVERAGE

S.H. Al-Hamdani. “Precision Farming in Northern Alabama”, Yarmouk University Seminar, Irbid, Jordan. June 2001.

S.H. Al-Hamdani. “Precision Farming in Northern Alabama”, American Society of Plant Physiologists Meeting, poster session, San Diego, CA, July 2000.

S.H. Al-Hamdani. “Precision Farming in Northern Alabama”, Association of Southeastern Biologists 62nd Annual Mtg., New Orleans, LA, April 2001.

Betts, M.T., T.D. Tsegaye and T.L. Coleman. 2000. “Positional similarities and dissimilarities of near surface soil temperature under bare and vegetative plots. *In* *IEEE Proceedings International Geoscience and Remote Sensing Symposium (IGARSS'00)* July 24 – 28, 2000. pp. 2939 – 2942, Honolulu, Hawaii.

Sullivan, D.G., J.N. Shaw, P.L. Mask, D. Rickman, J. Luvall, J.M. Wersinger and M.L. Norfleet. 2002. Quantifying Residue Coverage via Handheld and Aircraft Remote Sensing Platforms. p.207-212. *IN* E. van Santen (ed.). 2002. Making Conservation Tillage Conventional: Building a Future on 25 Years of Research. *Proc. of 25th Annual Southern Conservation Tillage Conference for Sustainable Agriculture*. Auburn, AL 24-26 June 2002. Special Report no. 1. Alabama Agric. Expt. Stn. and Auburn University, AL 36849. USA.

Shaw, J.N., J. Luvall, D. Rickman, P. Mask, J.M. Wersinger, and D. Sullivan. 2002. Application of Thermal Infrared Remote Sensing for Quantitative Evaluation of Crop Characteristics. *Proceedings of Workshop on Multi/Hyperspectral Technology and Applications*, Univ. AL, Huntsville. Feb. 6th and 7th, 2002, Redstone Arsenal.

Sullivan, D.G., J.N. Shaw, D. Rickman, P.L. Mask, J. Luvall, and J.M. Wersinger. 2002. High Resolution Multispectral Remote Sensing of Crop Residue. *Proceedings of Workshop on Multi/Hyperspectral Technology and Applications*, Univ. AL, Huntsville. Feb. 6th and 7th, 2002, Redstone Arsenal.

Sullivan, D.G., J.N. Shaw, P.L. Mask, and J.M. Wersinger. 2002. Using IKONOS imagery to predict soil properties in two physiographic regions of Alabama. *In* 2002 Agronomy Abstracts. ASA, Madison, WI.

Sullivan, D.G., P.Mask, J.N.Shaw, D. Rickman, J. Luvall, J.M. Wersinger, and C. Dillard. 2002. Monitoring Residue Cover Using Airborne Remote Sensing. p. 59. *In* 2002 Abstracts for the 5th Annual National Wheat Industry Research Forum.

Sullivan, D.G., P.Mask, J.N.Shaw, D. Rickman, J. Luvall, J.M. Wersinger, and C. Dillard. 2001. Airborne Remote Sensing of Surface Soil Properties. p. 54. *In* 2001 Abstracts for the 4th Annual National Wheat Industry Research Forum.

Sullivan, D.G., J.N. Shaw, P. Mask, E. Guertal, M. Norfleet, J. Luvall, D. Rickman, and J.M. Wersinger. 2001. Remote Sensing of Crop Residue Cover. *In* 2001 Agronomy Abstracts. ASA, Madison, WI.

Sullivan, D.G, J.N. Shaw, P.Mask, D. Rickman, J. Luvall, J.M. Wersinger, and C. Dillard. 2000. Estimating Soil Organic Matter Distribution in a Conservation Tillage System Via Remotely Sensed Data Analysis. p. 67. *In* 2000 Abstracts for the National Wheat Industry Research Forum.

Sullivan, D.G, J.N. Shaw, P.L. Mask, D. Rickman, J.Luvall and J.M. Wersinger. 2000. High resolution remote sensing for evaluation of soil properties. p.300. *In* 2000 Agronomy Abstracts. ASA, Madison, WI.

Sullivan, D.G., J.N. Shaw, P. Mask, D.Rickman, J.Luvall, J.M. Wersinger, D.E.Kissel, and L.T. West. 1999. Utilizing Remotely Sensed Electromagnetic Data to Approximate Soil Organic Matter Content. *In* Abstracts for the National Remote Sensing Applications Conference and Workshop. Auburn, AL.

Sullivan, D.G., P. Mask, J.N. Shaw, D. Rickman, J. Luvall, and J.M. Wersinger. 1999. Utilization of geospatial applications to enhance crop production and environmental quality. p. 332. *In* 1999 Agronomy Abstracts. ASA, Madison, WI.

Sullivan, D.G., P. Mask, J.N. Shaw, D. Rickman, J. Luvall, J.M. Wersinger and C. Dillard. 1999. Estimating Productivity of a Corn Crop via Remotely Sensed Image Analysis. *In* Abstracts for the National Remote Sensing Applications Conference and Workshop. Auburn, AL.

Sullivan, D.G., J.N. Shaw and P.L. Mask. 2002. Quantifying residue cover via satellite remote sensing platforms. 2002 Southern Conservation Tillage Field Day. (6/26/02).

Sullivan, D.G., J.N. Shaw, J.M. Wersinger, P. Mask. 2000. Remote sensing of natural resources. Alabama Water Resources Conference and Symposium.

The Anniston Star. Farming: Technology puts every acre to good use, Page 1B, Sept. 4, 2002

C. PROPOSALS SUBMITTED (NOT FUNDED)

Twelve were submitted and seven proposals were funded in the amount of \$83K

Project title: Site-Specific Agriculture for Improving Profitability Of Southeastern Producers
Investigators: J.N. Shaw, D.W. Reeves, C.W. Wood, P.L. Mask, J.M. Wersinger, D. Rickman
Sponsor: IFAFS-CSREES
Amount: \$934,847

Project title: Advanced Remote Sensing for Improving Crop Production In Alabama
Investigators: J.M. Wersinger-J.N. Shaw (Co-PI's), E. Oks, P.L. Mask, and K.L. Bowen
Sponsor: NASA EPSCOR- Research Compendium Program
Amount: \$170,000/yr- 3 years- \$540,000

Project title: Using Soil and Thermal Infrared Remote Sensing Data to Assess Aflatoxin Contamination Susceptibility in Peanuts
Investigators: J. N. Shaw, K. L. Bowen, D. L. Hartzog, P.L. Mask, J.M. Wersinger, D. Rickman, J.F. Adams, D.W. Reeves
Sponsor: Pre-proposal for Southern Peanut Research Initiative

Project title: Non-Invasive Soil Mapping for Non-Point Source Pollution Assessment
Investigators: T. Tsegaye, W. Tadesse
Sponsor: USDA Capacity Building Grant
Amount: \$300,000

Project title: Sustainable Poultry Litter Management: Short Rotation Hardwoods Integrated with Hyperspectral Remote Sensing and GIS
Investigators: T. Tsegaye, W. Tadesse
Sponsor: USDA Capacity Building Grant
Amount: \$269,146

D. PROPOSALS (FUNDED)

Project title: Utilizing Yield Maps and Remote Sensing Imagery to Optimize Nitrogen Fertilizer Rates for Corn

Investigators: P. L. Mask, J.N. Shaw, D. Sullivan, and C. Dillard.

Sponsor: Alabama Farmers Federation Wheat and Feed Grain Committee

Amount: \$8,000

Duration: 3/1/02 to 2/28/03

Project title: Evaluating Percent Residue Cover as it Relates to Soil Organic Matter via Remote Sensing

Investigators: D.G. Sullivan, J.N. Shaw, and P.L. Mask.

Sponsor: Alabama Farmers Federation Wheat and Feed Grain Committee

Amount: \$7,500

Duration: 3/1/01 to 2/28/02

Project title: Utilizing Yield Maps and Remote Sensing Imagery to Optimize Nitrogen Fertilizer Rates for Corn

Investigators: P. L. Mask, J.N. Shaw, D. Sullivan, and C. Dillard.

Sponsor: Alabama Farmers Federation Wheat and Feed Grain Committee

Amount: \$8,000

Duration: 3/1/01 to 2/28/02

Project title: Estimating Soil Organic Matter in Grain Fields Using Remotely Sensed Imagery

Investigators: D.G. Sullivan, J.N. Shaw, and P.L. Mask.

Sponsor: Alabama Farmers Federation Wheat and Feed Grain Committee

Amount: \$4,800

Duration: 3/1/00 to 2/28/01

Project title: Utilizing Yield Maps and Remote Sensing Imagery to Optimize Nitrogen Fertilizer Rates for Corn

Investigators: P. L. Mask, J.N. Shaw, D. Sullivan, and C. Dillard.

Sponsor: Alabama Farmers Federation Wheat and Feed Grain Committee

Amount: \$8,000

Duration: 3/1/00 to 2/28/01

Project title: Evaluation of Soil Sampling Techniques For Optimum Profitability

Investigators: P. L. Mask, J.N. Shaw, and D. G. Sullivan

Sponsor: Alabama Farmers Federation Wheat and Feed Grain Committee

Amount: \$8,000

Duration: 3/1/00 to 2/28/01

Project title: Development of environmental surface condition indicators from satellite data for delivery to users on the Alabama From Space website
Investigators: J.M. Wersinger, L.J. Marzen and J.N. Shaw
Sponsor: AUEI Small Competitive Grants Program
Date: April 2003-Mar 2004
Amount: \$38,494

E. STUDENTS GRADUATED/PARTICIPANTS

16 undergraduates, 5 graduate students and 8 faculty members were directly participating in this research cluster. One student completed his PhD during the course of the program and three completed MS degrees. One hundred twenty students and faculty participated in the Remote Sensing Applications conference held in Auburn in 1999 and the outreach component is estimated to have reached over 3,000 people, including ten agricultural agents, and dozens of farmers.

B.P. Nichols (JSU) completed his MS degree and now is in the PhD program at the University of South Florida

S. Blair (JSU) completed her MS degree and is a faculty member at UAB

K. Swenson (JSU) completed his MS degree and is a faculty member at Floyd Community College in Rome, Georgia.

S. Mattingly is in the process of completing her MS degree at JSU

Sullivan, D.G. 2003. Remote sensing of agronomic properties. Ph.D. Agronomy. Auburn University, Auburn, AL.

F. OTHER OUTREACH AND COLLABORATIONS

* Collaborations with others included SAR remote sensing support from Dr. Doran Baker, Utah State University and the Director of the Rocky Mountain Space Grant.

* Collaborations with NASA scientists included assistance in development of an undergraduate geospatial information technologies course, assistance with the Agricultural Extension Agent trainings, and development of a website, "Alabama from Space" featuring bi-weekly biomass landcover images and a greenness index. The website will also make use of existing archived satellite images of Alabama to show changes in land use since the early 1970s.

* As a result of our efforts on campus, the Department of Geography in the College of Science and Mathematics has hired a new young Assistant Professor, Dr. Luke Marzen who is working with our group. He now teaches the Remote Sensing class developed under this project.

* Collaborations with Utah, Arizona and Mississippi Space Grants' Geospatial Extension Specialist Program were involved in Alabama's development of its County Agent training course that took place in FY 2000-01. Dr. Mask was directly involved in seeing this program through to completion including training 10 agents in GIS/GPS remote sensing.

* The 1999 conference in Auburn on "Remote Sensing Applications" was supported in part by ASGC together with several other SG Consortia in the SE and by former Code FE. The conference brought together 120 participants from across the nation as well as Julius Dasch and Alex Tuyahov of Code Y0, people from Stennis Space Center and Marshall Space Flight Center.

APPENDIX C: METRICS

NASA EPSCoR Continuation Grant
NCC5-165

State	Patents and Publications			New Grants		Participants			Collaborations				
	Peer Reviewed Pubs.	Other Pubs.	Present.	Patents	New Grants	New Grants Value	Undergrad Students (cum)	Graduate Students (cum)	Post-Doctoral	Faculty	Collabs. w/ NASA Centers	Collabs. w/ Industry	Collabs. w/ Others
Alabama	12	69	5	58	9	32	\$1,764,000	30	28	23	5	8	17

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

UAH Proposal 99-354

**NASA EPSCoR
STATE OF ALABAMA PROGRAM**

Continuation of NCC5-165

Submitted to

**National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, MD 20771**

Prepared by



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Submitted by

The University of Alabama in Huntsville



Sue B. Weir
Research Administrator

May 1999

INTRODUCTION

This proposal is for a continuation (6th year) of the Alabama NASA EPSCoR research infrastructure building program. The two main clusters: a) Advanced Materials Development and b) Remote Sensing, Hydrology and Land Use Studies, are continued but a significant shift in the scope and approach to both cluster programs is being phased in this year to bring the programs more into line with the new NASA EPSCoR requirements and goals.

The impact on the two clusters is summarized as follows. Both programs are reduced in size to about 80% of prior funding.

The Advanced Materials component, consisting of the University of South Alabama (USA), the University of Alabama in Huntsville (UAH), the University of Alabama at Birmingham (UAB), the University of Alabama (UA), Auburn University, Samford, and the Alabama School of Math and Science, will continue its excellent program record of publishing papers and patents, involving graduate and undergraduates in original research, and writing mainline proposals. In addition, significant effort will be spent by the group towards defining and establishing a State research initiative in MicroElectro-Mechanical Systems (MEMS), building upon established capability in materials, thin films, and sensor technology. The scope of the new focus will seek the best combination of existing capability, expectation for future development, industrial collaborators and agency requirements. Significant MEMS interests have been identified at JSC, JPL, and GRC. One or more workshops are planned and it is anticipated that the effort will lead to the establishment of an enlarged R&D group in the State, which will join together in writing a number of proposals. Other ongoing research as described below will also be performed.

The Remote Sensing project has undergone a major restructuring. The prior project will be completed this year, including the publication of results, or submission for publication. This coordination will be still under the direction of the Phase I Project Director, George Cline of Jacksonville State. The new project, which builds upon the good success of the 1998 Alabama Space Grant Pilot Program in Precision Farming will be directed by J-M Wersinger of Auburn University and Paul Mask of the Alabama Cooperative Extension. NASA MSFC (Doug Rickman in Global Hydrology) is also a Co-Investigator along with representatives from Alabama A&M University (AAMU), Miles College, and Samford University.

STATEMENTS OF WORK

Advanced Materials Cluster

University of South Alabama

Nanostructured Laser Processed Superhard Composite Coatings. Nanocrystalline materials have been attracting rapidly increasing interest in the last decade and have the potential of revolutionizing traditional materials design in many applications via atomic-level structural control to tailor the engineering properties. The objectives of this research program are to fabricate nanocrystalline carbon nitride (CN_x) coatings for manufacturing applications. The proposed research is directed toward the development of superhard coatings based on mixed nanocrystalline phase. The innovativeness and originality of the proposed work consists in creating unique microstructure in which (a) the grains of a nanocrystalline, hard phase are surrounded by an amorphous and hard grain boundary phase, and (b) a graded transition layer of mixed morphology is deposited in which a solid lubricant phase is added to provide the necessary low coefficient of friction on the surface of coatings for metal-curing applications. The research objectives will consist of establishing conditions for deposition of nanocrystalline/amorphous composite coatings by pulsed laser deposition (PLD) process. For the demonstration of the feasibility of the concept, we have chosen the CN_x/Si₃N₄ composite coating. The presence of silicon nitride in the coating is expected to impart improved oxidation resistance over a single-phase CN_x coatings.

The state-of-the-art analytical technique will be used to evaluate the structural and mechanical properties. The ultimate goal of this research is to develop the science and technology base leading to some real-world applications of carbon nitride thin film coating. The proposed research will also provide students with an opportunity early in their college career to investigate and practice some general principles of materials manufacturing and processing to solve a real-world problem related to the process of design for manufacturability, tool selection, and tool path optimization. Results of the project will be disseminated by paper presentation in regional and national conferences, and published in journals.

The technical objectives in this project can be enumerated as follows:

1. PLD of nanocrystalline CN_x/Si₃N₄ composite coatings on steel substrates
2. Characterization of microstructure and composition
3. Evaluation of surface hardness and tribological properties

Potential Commercial Applications: It is anticipated that advanced tribological coatings of hardness > 5000 kg/mm² and friction coefficient < 0.2 will have tremendous impact on the machining industries for space applications. A bigger market opportunity is expected to be created by extending the application window for such coatings will address significantly manufacturing issues of increased productivity, reduced environmental pollution due to cutting fluid and extended life of tools and machinery. The achievement of these goals is clearly a critical factor in improving the global competitive strength of the U.S. manufacturing sector.

The University of Alabama in Huntsville

Growth and Characterization of Novel Materials with Potential Applications in Nanotechnology. Michael A. George, P.I. The focus for this proposed research is the study of the nucleation and growth processes of novel materials. These materials are at present being studied by NASA researchers in the areas of microgravity science and in the development of microelectromechanical (MEMs) devices. In addition to the study of the growth processes, we will explore the potential development of new applications for these materials. These applications will be primarily associated with advances in nanoscale MEMs sensors. The project will employ materials that are presently being grown and developed by NASA researchers to address needs by NASA for advanced devices in both ground and space based missions.

Materials that we will investigate include wide bandgap semiconductors, zinc selenide and silicon carbide. These are typically grown by physical vapor transport techniques. In addition, we will begin to examine other significant materials of interest to NASA including bio-organic and polymer thin films. Although clearly different, these materials follow similar fundamental nucleation and growth processes thus the chemical and interfacial effects that the films have on substrates should provide results that can be employed as relative baseline data. This work will build upon collaborations already established between the PI, Dr. Michael A. George and scientists at NASA-MSFC and NASA-GRC.

The University of Alabama at Birmingham

Microwave Plasma Processing of Nano-structured Diamond Coatings. Dr. Yogesh K. Vohra, P.I.

- Microwave plasma processing of nano-diamond films on one-inch diameter Ti-6Al-4V alloy coupons and curved engine rings. The films will be grown with varying Nitrogen/Methane ration from 0 to 0.4 in the gas phase.
- Nano-hardness and wear testing of nano-diamond coated coupons using the Universal Micro-Tribometer. Funds are being requested from NASA to acquire this facility at UAB.
- Correlation of the mechanical properties with processing parameters likes Nitrogen/Methane ratio and substrate temperatures and optimization of these processing parameters.

Our fundamental studies on the mechanical properties of the nano-structured diamond coatings on titanium alloy will provide the science base in deciding on the optimal processing conditions for a given application. Also, the proposed research on curved engine rings will overcome a major technological barrier for widespread applications of nano-diamond coatings.

The University of Alabama (Tuscaloosa)

Microstructure and Mechanical Properties of Microlaminates. Dr. Viola Acoff, P.I. Gamma titanium aluminide is an advanced, lightweight alloy that can be used in numerous aerospace applications. There are three distinct microstructures of gamma titanium aluminide, single phase gamma (γ) fully lamellar (alternating platelets of α_2 and γ), and duplex (gamma grains plus lamellar grains), that can be obtained as a function of heat treatment. The fully

lamellar microstructure has the best creep properties and fracture toughness. It is believed that the properties of the lamellar microstructure can be controlled by altering the α_2/γ interface. Thus, the ability to engineer the α_2/γ interfaces to produce various morphologies of the lamellar microstructure can lead to better control of the microstructure and mechanical properties. This study proposes a method for producing engineered microstructures of lamellar gamma titanium aluminide using microlamination to enhance mechanical and creep properties. Microhardness and tensile testing will be performed to compare the mechanical properties of the engineered lamellar microstructures to those produced using conventional heat treatments. Nanoindentation will be used to determine the properties of the α_2/γ interfaces.

The PI will devote one summer month to this project. One graduate student will assist.

Auburn University

Liquid Solution Based Diamond Deposition Technology and Applications. Yonhua Tzeng, Principal Investigator. Hydrogen and methane in the form of compressed gases are used for the chemical vapor deposition of diamond films and diamond-like carbon films. A new and better technique for diamond deposition has been developed in our laboratory at Auburn University. In this new process, no compressed gas of any kind is needed. Instead, a liquid solution is fed into the deposition chamber. Either a plasma is generated in the vapor of this solution or a high-temperature filament is applied to decompose the vapor, resulting in the production of O, OH, H, CH₃, etc. radicals for diamond deposition. This process is relatively safe and economic compared to other traditional diamond CVD processes because compressed gases are not needed and the liquid solutions needed for diamond deposition are inexpensive.

Extensive studies on the liquid solution based diamond deposition process will be carried out in order to further optimize the production and cost effectiveness of this new diamond CVD process. Diamond manufactured using liquid solutions as the feedstock may have unique properties that will find special applications. It is, therefore, important to characterize the diamond films and diamond plates that are produced by the new process. Besides high quality diamond, it is also possible to manufacture carbon films with properties similar to diamond while being more compatible with other materials for commercial applications. For example, diamond-like carbon films and nano-crystalline diamond coatings may also be manufactured using the liquid solutions as the feedstock. A systematic study is planned for exploring the potential of the liquid solution based diamond CVD process.

Samford University

Previous work has shown that thin-film interference effects are present in optical pyrometric measurements taken during diamond film growth [Catledge, SA, Comer, W and Vohra, YK, *In-situ Diagnostics of Film Thickness and Surface Roughness of Diamond Films on Ti-6Al-4V Alloy by Optical Pyrometry*, *Appl. Phys. Lett.* 73, 181 (1998)]. Recent work has shown that interference fringes are also observable using laser illumination of the growing film via side ports of the resonance cavity. This setup will be modified to allow for the simultaneous measurement of temperature and laser interference data. Initial studies have been with a 1.2 KW system; modification and implementation on a 6kW system will also be undertaken. Computer modeling of these thin-film interference effects will also be investigated; this model will include surface-roughness effects and the correlation of scattered light with reflected light.

Alabama School of Math and Science

Two students from ASMS will work during the summer with Dr. Ashok Kumar and Dr. Wattuweha at the University of South Alabama. Their task is to analyze thin film samples which deposit in the Pulsed Laser Deposition (PLD) system, using SEM and XRD. They will prepare samples and analyze them for graduate students to gain more hands on experiences. They will learn the practical applications of these films. They will also work on literature search on the area they work on. Learning the operation of the PLD and high vacuum system, data acquisition, trouble shooting, and safety are the major concentrations of work. This work may most likely continue during the regular quarters beyond the summer.

The other involvement includes learning process of CVD system. In addition to the chemistry of the system, they will make an attempt to optimize parameters such as gas pressure, gas flow, and the temperature to grow good crystallized diamond and to use SEM and XRD to analyze the quality of diamond films.

Remote Sensing Cluster

Auburn University

Remote Sensing for Site-Specific Agriculture in Alabama. Dr. Jean-Marie Paul Wersinger, P.I. 1. *NASA Earth Science Applications:* One of the goals of the NASA-EPSCoR is to encourage and fund research in areas defined as NASA priorities. An area of rapid growth within the Earth Science Enterprise (ESE) at NASA is the newly established Division of Earth Science Applications. Dr. Nancy Maynard – the leader of this Division – has the goal to make ESE Applications' budget 10% of the total ESE budget. This represents about \$180 Million/year. ES Applications seeks to "develop, test, and validate applications of ESE science and data to high-priority problems in cooperation with representative organizations and/or individuals in these sectors." Two of these organizations are Space Grant and Cooperative Extension. Agriculture is one of the areas most often mentioned by ES for application of remote sensing. Agricultural topical priorities for ES Applications are: precision agriculture, crop yield prediction capabilities, vegetation and soil variability, soil characterization using remote sensing, change detection, resource management decision support models and assessment of damages to the environment resulting from anthropogenic stresses.

Our proposal responds very adequately to these requirements. Our objectives are:

1. to use remote sensing data from ATLAS and other sensors to develop yield variability prediction models within fields for various crops,
2. the development of SSA resource management decision support models using the output of the yield variability prediction models and
3. the assessment of the reduced impact of SSA practices on the environment.

Both ASGC and Alabama Cooperative Extension will be involved in this project.

2. Site-Specific Agriculture: Site-specific agriculture (SSA) utilizes geospatial technologies (global positioning systems-GPS, geographic information systems-GIS, and remote sensing-RS) to delineate management zones and farm soils based on their autonomous properties. Many studies have been conducted evaluating the benefits of SSA for maximizing crop production. Although SSA has not been adopted by the majority of the agricultural community as of yet, current trends suggest most row crop operations will adopt at least some aspects of SSA within the next few years. Research has shown SSA may also reduce the off-site movement of nutrients and agrochemicals, and thus may provide a viable way of limiting row-crop contributions to non-point source (NPS) pollution. Because agriculture has been cited as a major contributor to NPS pollution, and nutrient enrichment in freshwater systems is a problem in AL, the evaluation of SSA as it relates to NPS impacts is essential.

Site-specific agriculture uses RS data: 1) as a base map on which yield or fertility data are overlaid in a GIS; 2) to delineate management zones, based on soil properties (mainly surface organic matter content) or crop canopy reflectance values, for facilitating variable rate application of fertilizers and pesticides; 3) to evaluate soils as per their pesticide sequestration potential (mainly based on soil organic matter amounts) and thus minimization of environmental impacts; 4) for crop growth modeling input; and 5) to predict crop yields based on soil properties or spectral reflectance of crops at juvenile growth stages.

Definition of Work: A NASA Learjet with the Atlas sensor on board will fly over three fields in Alabama. The first flight will remotely sense bare soil on the three sites and takes place in May. The second flight will sense the crops in late June, early July to detect stress. Starting in May and ending at harvest time, soils and plants will be sampled on the ground. Maps of soils, chemicals and nutrients will be made based on ground analyses. At harvest combines with yield monitors will provide the data for yield maps. An in-depth study of correlation between these maps and remote sensing derived maps for plant stress will be made after harvest.

Concomitantly with the yield studies, a study of environmental impact of precision farming will be made at the three sites.

Presently, participants in the complete project are scientists from Auburn University, the Global Hydrology and Climate Center in Huntsville, and Alabama A&M University. Other institutions have expressed interest: Jacksonville State University, Samford University and Miles College. Collaborative work will be discussed with representatives of these institutions in a meeting to take place at Auburn University on May 14. The PI of this proposal will act as a coordinator for the collaborative work.

A complete report of results will be available in April 2000.

The tasks performed by Auburn University scientists and students will be:

1. Soil sampling and analysis
2. Nutrient sampling and analysis
3. Plant sampling and analysis
4. Analysis of RS data from Atlas sensor and Landsat 7 under leadership of Doug Rickman of the GHCC
5. Producing yield maps from yield monitor and GPS data
6. Producing soil, nutrient and plant health maps

7. Statistical analysis of the soil, nutrient, plant health and RS maps in collaboration with Doug Rickman
8. Coordination for the overall project.

Scientists at AAMU will purchase Landsat 7 data and analyze them. Studies of correlation between Atlas and Landsat 7 data will be collaborative work between AAMU, AU, and GHCC.

Miles College

The objectives of our study are:

- to introduce students to scientific inquiry and reporting, also, to familiarize participants with GPS technology;
- to introduce Miles College students to the NASA world of remote-sensing technology and its application to the needs of farmers and other land users; and
- to help local community groups in developing information concerning the quality of water resources close to them.

Jacksonville State University

Precision Farming in Northern Alabama. Safaa Al-Hamdani and David Whetstone. Dr. George Cline, P.I. A principal objective is to specifically correlate leaves temperature and optical properties of cotton (*Gossypium hirsutum*), soybeans (*Glycine max*), and corn (*Zea mays*), with satellite imagery. Plant light absorption, reflectance, and transmitted light values for wavelength between 380-1700 nm during different stages of these crops' growth and development will be determined.

A Licor (1800) will be used to determine absorption, reflectance and transmitted light values for each type of crop during critical stages for seedling development, flowering, and during fruiting. Spectral determinations will be in the 380-1700 nm range. Optical measurements will be correlated with chlorophyll a, b, and carotenoids. Yields will be measured by sacrificing several plants from each sample site. Plant dry weight will be measured (in grams), with fruits being weighed separately to determine production per area. Remote sensed images will be ordered for specific sites during peak times for correlation studies. Images will be analyzed for specific reflectance values and correlated with ground truth studies during the three phases for each species. Field studies will commence during July 1999 and proceed until harvest time during September and early October in 1999. Three sites will be selected for each crop. A standardized sampling regime will be imposed within each field. Soil samples will be forwarded to the soils laboratory during each collection period for nutrient analysis. We will process materials immediately following field sampling. This experiment will be established as completely randomized block design. Each selected field will be considered an individual block. Mean separation will be evaluated using LSD.

In order to increase the interaction of the JSU Remote Sensing Cluster and NASA scientists, participants in this project will work with Dr. J.M. Wersinger, Auburn University and NASA Fellow. The work will focus on the precision farm outside of Jacksonville, AL, and at the

precision farm in Decatur, AL. These sites are part of the NASA funded study to Dr. Wersinger (Remote Sensing for site specific agriculture in Alabama). Considerable time and money is partitioned to provide students and faculty to interact with Dr. Wersinger, Dr. Paul Mask (Ag. Extension Specialist at Auburn University), and Dr. Doug Rickman (Marshall Space Flight Center) to coordinate their research methods and learn from their expertise.

Alabama A&M University

The objectives for participating in the proposed project will focus on the crop stress detection/monitoring and crop yield prediction/assessment using remote sensing/GIS/GPS techniques for precision agriculture practices. We believe that we have the experience, expertise, and capabilities in this area, which will assist in the accomplishment of the overall goals of this project.

The Center for Hydrology, Soil Climatology, and Remote Sensing (HSCaRS) laboratory (at A&M University) is involved in research and development of new and more efficient ways of extracting information from digital spectral data obtained from multiple band spectral sensors. The Center's scientists have strong experience and expertise in cutting edge techniques in remote sensing, GIS, and GPS technology as applied to land use, natural resource, environmental, and agricultural related problems. Remote sensing research techniques are currently being utilized in the areas of precision agriculture, land use/land cover and watershed management; computer simulation modeling; differentiating surface soils and soil properties; forest evaluation, inventory and monitoring; crop assessment and inventory; water quality; and geographic information system (GIS) development and modeling.

Samford University

C. Victor Wu, P.I. In the extended year of the project, Samford University would like to investigate the scale dependency issue in precision farming. Details of the research plan are described as follows:

Despite the many potential benefits of precision farming, it is economic feasibility that eventually determines whether the practice of precision farming will be widely accepted and successful. The idea of precision farming is to employ fine-tuned information to conserve farming costs and to increase profit (by more wisely applying fertilizer and pesticide to where they are needed). The practice can, however, be a quite costly undertaking. For instance, the costs of acquiring remotely sensed data prove prohibitively expensive for many farmers to date. Given the important role of remotely sensed data in precision farming, it is only logical to select the appropriate remotely sensed data both in the sense of cost and the quality of information. Data from earth resource satellites such as Landsat are a sensible selection with their extensive and frequent coverage, and, of foremost importance, affordable price tags. While the new generation of earth resource satellites are reported to offer improved data quality, data from these satellites are still less satisfactory than that from airborne vehicles, due to complications of imaging a large geographic area, atmospheric effects and other factors.

Research is needed to determine whether satellite-borne data would meet the needs of precision farming, or whether airborne data are necessarily superior to satellite borne data in revealing farming conditions. Proposed here is to compare airborne images with satellite-borne images with respect their resolution and usability in precision farming. Specifics need to be

worked out when the airborne remote sensing vehicle's mission plan is made available. With our strength in geographic information systems (GIS), Samford is proposing to apply GIS tools to examine the scale dependency issues in various remotely data bases required for precision farming, and to develop feasible sampling strategies that can benefit precision farming in general.

The University of Alabama in Huntsville

**To Support Research Activities Under the NASA
Experimental Program to Stimulate Competitive Research
(EPSCoR)**

Annual Progress Report

**Dr. John C. Gregory, Principal Investigator
Laboratory for Materials Surface Science**

June 1, 1998 – May 31, 1999

**The University of Alabama in Huntsville
Office of Research Administration
Research Institute/Room E-12
Huntsville, AL 35899**

NCC5-165

Alabama NASA-EPSCoR Fifth Annual Report

I. Progress in Research Capabilities

Cluster Organization of Research Projects

Research activities of Alabama NASA-EPSCoR are organized under two clusters: an Advanced Materials Cluster and a Remote Sensing Cluster. Since the nature of the activities and the manner in which they relate to one another differ by cluster, these clusters function independently and are summarized in parallel in this report. They do share a common administration by the Alabama Space Grant Consortium and by this means, good ideas from each group are communicated to the other, as appropriate. Reports from all participating institutions are provided for reference in Appendices A (Advanced Materials Cluster) and B (Remote Sensing Cluster).

Advanced Materials Cluster

A multi-disciplinary research consortium has successfully achieved the milestones of research objectives in the fourth year of the NASA-EPSCoR grant to Alabama in the areas of the design, fabrication and characterization of advanced materials for electronic, optical, and mechanical applications. The objective of this research program is to investigate means by which materials performance may be enhanced through engineered interface and surface modifications. The cluster is organized under six projects that have favorably impacted the research infrastructure of the state and has improved human scientific resources at the pre-college and college/university levels during the four years. In this fifth year 8 institutions (listed by project in Section II) participated, involving 8 scientists, 15 graduate students, 1 undergraduate, and 4 high school students. The research programs have provided both graduate and undergraduate students with opportunities in their college careers to investigate and practice some general principles of materials science to solve real-world problems related to the process of design for manufacturability, tool selection and tool path optimization. The cluster has also made specific linkages with personnel at two Historically Black Colleges and Universities (HBCU's). The following objectives have been achieved through the NASA-EPSCoR research grant during the fifth year (described in detail in Section II and Appendix A): a) perform and publish world-class research; b) educate students in relevant science and engineering disciplines; c) enhance the technology infrastructure in the State of Alabama in order to stimulate expansion of high technology industries; d) reach out to stimulate the interest of minorities towards careers in science and engineering.

This cluster is organized under six different projects, each involving one or more institutions. Each project is based on and helps develop the capabilities of the researchers at the respective institutions. It is within these projects that the smaller, non-research institutions are coupled with mentoring universities having more established research activities. These smaller institutions provide undergraduate research assistants, who become involved in the research project which is carried out at the larger university, enabling them to do research not available to them at their

home institutions. These are discussed in terms of the specific projects in Section II below. In addition, the projects themselves relate to one another so that the output or product of one project becomes one of the inputs or materials to be tested in another; thus, an extrinsic collaborative network has been formed among faculty, students, and the various institutions involved. In this way seven faculty linkages and two student linkages have been established among the cluster institutions in the fifth year. These represent a major enhancement of Alabama's research/educational infrastructure, particularly in the opportunities they provide for faculty and students at the smaller institutions. Collaborations also extend to four research groups in other universities (beyond the cluster), to six groups in government laboratories and to six industry groups. In this fourth year, this cluster has 30 papers at various stages of the publication cycle, has completed seven theses or dissertations, has presented 17 papers at national or international meetings, and has submitted proposals totaling, \$2353.3K of which \$923.3K have been funded, the remainder pending.

Remote Sensing Cluster

The activities of this cluster are focused on four primary tasks, which are closely interrelated and contribute to a common overall objective. The remote sensing cluster tasks are much more interdependent than those of the advanced materials cluster, and in this sense, require significantly more group interaction in the planning, training and decision-making activities. Although the natures of the tasks are different, they all focus on the same geographical locations and the determination of these locations is such that they must represent conditions that take into account factors affecting the individual tasks in different ways. Five institutions are participating in this cluster: Jacksonville State University (JSU), Alabama A & M University (AAMU), Athens State College (ASC), Miles College (MC), and Samford University (SU), two of which are HBCU's. From these institutions, 13 scientists, 1 undergraduates and 11 graduate students have been actively involved in the fifth year. In this fifth year, this cluster has six papers at various stages of the publication cycle, and has submitted proposals totaling, \$7625.6K of which \$51.7K have been funded, the remainder pending.

Administrative Activities

The Alabama NASA EPSCoR program is administered by the Alabama Space Grant Consortium (ASGC) through the University of Alabama in Huntsville (UAH). Dr. John C. Gregory, Director of ASGC is the Alabama NASA EPSCoR Project Director, and Dr. Richard H. Comfort serves as Associate Director. NASA funding of the research activities is transmitted to the participating institutions by means of a subcontract from UAH (the lead institution) in accordance with amounts specified in the proposed cost plan.

A fall meeting of the Advanced Materials Cluster was held on September 12, 1998 at the University of Alabama at Birmingham in conjunction with the Twelfth Annual Alabama Materials Research Conference. The Remote Sensing Cluster held a fall meeting on October 9, 1998 at Samford University in Birmingham. The activities of the summer were reviewed and plans were made for bringing results to closure. Dr. Gregory joined personnel from other Alabama EPSCoR programs at Auburn University on February 24-25, 1999 to discuss EPSCoR research and infrastructure development activities in Alabama. Spring cluster meetings for both clusters were held in Birmingham on March 19, 1999 to discuss the future of the program.

II. Progress in Individual Research Projects

Advanced Materials Cluster

Project 1: Laser Processed Surface Modification, Coating, and Thin Films (Coordinator: Dr. A. Kumar, University of South Alabama and Dr. Garvin Wattuhewa, Alabama School of Mathematics and Science)

We have used our state-of-the-art thin-film-related research to investigate making multifunction type of coatings for applications in the commercial and space sectors. We have deposited excellent quality hard coatings of carbon nitride (CN_x), cubic boron nitride (cBN), diamond-like carbon (DLC) and microlaminate coatings of metal/ceramic by the pulsed laser deposition method. Evaluation of mechanical properties was done using the nano-indentation method. Microstructural analysis was carried out, which included i) x-ray analysis for lattice structure, ii) scanning electron microscopy, TEM, atomic force microscopy (AFM) for grain structure and lattice microstructural information.

Project 2: Novel Processes and Applications of CVD Diamond, Cubic Boron Nitride, and High-Tc Superconductors (Coordinator: Dr. Yonhua Tzeng, Auburn University)

Manufacturing costs for diamond can be greatly reduced if the feedstock for diamond deposition is in the form of some kind of inexpensive liquid solutions. This will be especially useful if diamond can be deposited by both plasma enhanced chemical vapor deposition techniques as well as non-plasma processes, i.e. the hot-filament chemical vapor deposition technique. During this fifth year, two diamond deposition processes have been invented using only liquid solutions as the feedstock. They are the methanol-based microwave plasma enhanced diamond deposition process and the methanol-based hot-filament assisted diamond deposition process. Diamond of high quality can now be deposited on silicon, molybdenum, copper, aluminum, and many other substrate materials without using any compressed gas. Two provisional patent applications have been filed for these new diamond deposition processes.

Project 3 : Microstructure and Mechanical Properties of Microlaminates (Coordinator: Dr. Viola . , The University of Alabama)

This project has been supporting the work of a PhD student, Mr. Jian-Guo Luo. He has focused his efforts on the development of reaction sequences to achieve a complete reaction between titanium and aluminum foils in order to produce the intermetallic compound TiAl. Results of this research were reported at the Annual TMS Meeting in San Diego, CA, where Mr. Luo's presentation was awarded first place in the *Gamma Titanium Aluminides Symposium*.

Project 4: Microwave Plasma Processing and Gas Phase Diagnostics for Diamond Coating of Curved Surfaces of Aerospace Materials (Coordinator: Yogesh Vohra, Department of Physics, University of Alabama at Birmingham with Dr. John T. Tarvin, Samford University)

Large Area Diamond Deposition System: A six kilowatt-microwave plasma chemical vapor deposition system has been acquired and installed, permitting diamond coating of a 4-inch substrate. A new substrate design has been implemented allowing for stable temperature

operation for twelve or more hours. Several experiments on metallic substrates, as well as diamond-on-diamond, have been successfully carried out.

Nano-diamond Coating on Titanium Alloys. We have demonstrated a new growth regime for synthesis of nan-crystalline diamond films in high-density plasma. For a plasma operating at a pressure of 125 torr, with a relatively high concentration of methane, a small amount of nitrogen causes nano-crystalline film formation. Crystalline diamond films have rough surface with a rms roughness of 270nm, typically requiring a post-growth polishing procedure for most applications. However, nano-crystalline diamond films are naturally smooth and have a rms roughness of only about 27 nm and would not require any post-growth polishing. There is also an increase in toughness exhibited by these nano-films as compared with the crystalline films, demonstrated by a Vickers indenter. Optimal deposition conditions have been found which yield films that are hard (hardness value of 92 Gpa) and exhibit a low coefficient of friction (0.08).

Project 5: Surface and Optical Characterization of Thin Films and Coatings (Coordinator: Michael A. George and Jeffery J. Weimer, University of Alabama in Huntsville)

In the area of the characterization of pulsed-laser deposited films and nano-clusters, we continued to examine the surface morphology and composition of wide band-gap semiconductor materials, primarily nitrides and carbides. A detailed study was performed on silicon carbide and silicon nitride powders produced by this technique.

In collaboration with NASA/MSFC scientists, characterization of crystal growth processes was performed on both Cr doped and undoped ZnSe crystals grown in a horizontal furnace and in a vertical furnace. The as-grown surfaces of the undoped horizontally grown crystals were dominated by (110) facets and steps, while the as-grown faces from the vertically grown crystals showed granular structures with tubular features on the surface. A study has been recently initiated to examine crystal growth using *in-situ* AFM techniques. We have begun to establish viable protocols to obtain reliable AFM images on protein crystal surfaces. We have been successful in obtaining AFM surfaces of monatomic steps and terraces on lysozyme protein crystal surfaces.

In collaboration with scientists at NASA Lewis and Alabama A&M, we are developing application for silicon carbide epitaxial films. The I-V properties of elevated temperature silicon carbide chemical sensors were measured as function of hydrogen, propylene, and methane exposure at elevated temperatures and sensor responses were observed for each gas. A linear increase with exposure for methane was the first such response for methane reported in the literature and is the subject of a patent disclosure for this sensor.

Project 6: Simulation and Numerical Analysis in Support of materials Processing (Coordinator: Dr. Ashok Kumar, University of South Alabama)

Laser-induced desorption and ablation result from the conversion of an initial electronic or vibrational photoexcitation into kinetic energy of nuclear motion, leading to the ejection of atoms, ions, molecules, and even clusters from a surface. In laser ablation process, design of processing experiment requires consideration of the coupling of the laser energy with target via the optical delivery system. There are several ablative mechanisms by which material, either atomic or bulk, can be released from the surface of the target. A computational model has been developed in order to simulate heat transfer with phase transition in laser ablation with or without the kinetics consideration. The front fixing method with Landau transformation has been

used to represent the geometric domain. Energy absorption, heat transfer (1-D heat conduction), melting model, and surface vaporization have been modeled to understand the ablation mechanism for simple systems. The spectral collection method has been utilized for special discretization in this model, while backward differentiation techniques have been used for temporal discretization. A one-dimensional model has been compared with the experimental results, but more work is needed to establish the 3-D model for multifunctional applications.

Remote Sensing Cluster

The cluster's efforts have revolved around several areas. The first group (Cline - JSU) has been analyzing plant community structure based on field collections made between 1994-1997. The methodology to do this is a new application of a form of correlation analysis; and the technique is found to be very sensitive to differences among plant communities. Characteristics of 37 lowland plant communities were sampled (Whetstone - JSU) at GPS sites along the Coosa River and classified using standard plant vegetation techniques. Wetland community types will be classified using standard wetland nomenclature. These sites will then be used to assess the availability of the various community types throughout the middle Coosa River drainage..

Water quality data has been collected from six locations along the Coosa River during satellite overflights (Romano, Al-Hamdani, Durrant - JSU). Data have been analyzed for turbidity and chlorophyll content (correlated with phytoplankton concentrations).

A combination of Landsat, SPOT, and high altitude photographic images have been used to collect and analyze urban/suburban development along Alabama Hwy 431 between Anniston and Gadsden over the last 20 years..

Landsat TM (20/36, 1996) image classification has been performed and a land cover map produced (Wu - SU). Plant community data received from JSU have been reorganized and converted to a digital database. A copy was sent to JSU for analysis in the biological research.

Scientists at AAMU (Coleman, Fahsi, Manu, Rajbhandari) completed the assessment of soil and vegetation conditions using hyperspectral data, GIS, and GPS technology. Results indicate that hyperspectral data could be used to determine the amount of nitrogen concentration in the soil and predict crop yield through leaf chlorophyll concentration. In addition, the data can also be used to detect nitrogen stress at site specific locations to optimize the application of nitrogen fertilizer.

In the Village Creek area of Birmingham, a study was carried out (Woods - MC) to identify and quantify water quality characteristics. The goal was to develop a reasonable description of the reservoir to aid in evaluating the effectiveness of remediation and recovery of alleged contaminants, as well as the impact of loss of bio-diversity.

GPS technology has been used to attempt to isolate a spectral signature for cedar glade habitat, based on data from the Prairie Grove Glade, the largest intact cedar glade in north Alabama. The glade is the habitat for a community of rare or uncommon vascular plants, including *Dalea folios* (leafy prairie clover), a federally designated endangered species. Output is scaled so that areas identified as cedar glades are assigned a color or number to indicate probability for its being a cedar glade. Areas so identified will be ground-truthed to determine validity of the technique.

III. Year Five Budget

APPENDIX A:
Annual Reports
Advanced Materials Cluster

**LASER PROCESSED SURFACE MODIFICATION, THIN FILM,
AND COATING**

ALABAMA NASA EPSCoR

**Annual Report
1994-1999**

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PUBLICATIONS

(i) Books/Chapters:

- (1) Hard Coatings Based on Borides, Carbides and Nitrides: Synthesis, Characterization and Applications, **Editors: Ashok Kumar, Yip-Wah Chung, and Ray W. J. Chia**, TMS (1998)
- (2) Surface Engineering: Science and Technology I, **Editors: Ashok Kumar, Yip-Wah Chung, John Moore, and John Smugeresky**, TMS, to be published Feb, 1999
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2. Ashok Kumar, R. B. Inturi, Y. Vohra, U. Ekanayake, N. Shu, D. Kjendal, G. Wattuhewa and J. A. Barnard "Mechanical properties of laser processed diamond-like carbon films" MRS Symposium Proceeding "Advanced Laser Processing of Materials", Vol. 397, 289-296 (1996)
3. D. Kjendal, Ashok Kumar, R. B. Inturi and J. A. Barnard "Pulsed laser deposition of poly(tetrafluoroethylene) films" MRS Symposium Proceeding "Advanced Laser Processing of Materials", Vol. 397, 223-228 (1996)
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5. Ashok Kumar, U. Ekanayake, D. Kjendal, N. Shu, R. B. Inturi and J. A. Barnard "Structural and mechanical properties of pulsed laser processed superhard coatings" TMS Annual Meeting High Temperature Coating II, 349-360 (1996)
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 8. H. L. Chan, U. Ekanayake, Ashok Kumar, M. R. Alam, Q. You, R. B. Inturi, N. Shu and J. A. Barnard "Nanoindentation Studies of Hard Coatings Prepared by Laser Ablation" Applied Surface Science, 109/110, 58-61 (1997)
 9. I. Hussain, Ashok Kumar, S. C. Perlaky, C. C. McCombs, F. Zhong, J. J. Weimer and L. Sanderson "Fabrication of Piezoelectric Sensors for Biomedical Applications" MRS Symposium Proceedings, Materials for Smart System, Vol. 459, 501-506 (1997)
 10. H. L. Chan, Ashok Kumar, L. Sanderson and J. J. Weimer "Atomic Force Microscopy study of Hard Coatings Films Prepared by Pulsed Laser Deposition Method" MRS Symposium Proceedings, Thin Film- Structure and Morphology, Vol. 441, 487-493 (1997)
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 12. Ashok Kumar, H. L. Chan, U. Ekanayake, A. Weirzbicki, N. B. Dahotre and S. C. Sikes "Laser Ablation Synthesis and Characterization of Carbide and Nitride Coatings" Journal of Materials Engineering and Performance, Vol. 8 (5), 577-582, (1997)
 13. Ashok Kumar, Q. You, A. Mangiarcina, J. S. Kapat, S. A. Catledge and Y. Vohra "Evaluation of Barrier Layer for HFCVD Diamond Films on Silicon Substrates" Thin Solid Films, vol. 308-309, pp 209-214 (1997)
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18. J. S. Kapat, Z. Wei and Ashok Kumar "Role of Kinetics of Transformation in Pulsed Laser Ablation" *Applied Surface Science*, vol. 127-129, 212-217 (1998)
19. Ashok Kumar, H. L. Chan and J. S. Kapat "Deposition and Characterization of Titanium Carbide Coatings Using Laser Ablation Method" *Applied Surface Science*, vol. 127-129, pp 549-552 (1998)
20. Ashok Kumar, H. L. Chan and R. Alexandrescu "The synthesis, characterization and mechanical properties of carbides and nitrides films prepared by pulsed laser deposition method" A. Crunteanu, R. Alexandrescu, R. Cireasa, I. Morjan, and Ashok Kumar "Deposition of carbon nitride thin films by IR laser-induced reactions in carbon-nitrogen gas-phase compounds" *ROMOPTO 97* (Fifth Conference on Optics. SPIE Proceeding, vol. 3405, 199-204 (1997)
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22. M. A. George, J. J. Weimer, and Ashok Kumar, "Characterization of Titanium Films Produced by Physical Vapor Deposition Techniques" *TMS Proceeding "Hard Coatings Based on Borides, Carbides, and Nitrides: Synthesis, Characterization and Applications"*, *Editors: Ashok Kumar, Y Chung and Ray W. J. Chia* , 203 (1998)
23. M. Shamsuzzoha and Ashok Kumar "A TEM study of epitaxial (100) TiC film grown on Si(100) substrates by pulsed laser deposition method, *TMS Proceeding*

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 30. Ashok Kumar, R. Alexandrescu, M. A. George, “Deposition and characterization of carbon nitride films by laser processed methods” MRS Symposium Proceedings Advances in Laser Ablation of Materials, Volume 526, 367- 372 (1998)
 31. Ashok Kumar and Q. You, “The effects of template layer of AlN on HFCVD diamond nucleation” International Symposium Proceeding World Ceramic Congress and Forum on New Materials (1998) in press
 32. Ashok Kumar, H. L. Chan, and Rodica Alexandrescu “Pulsed laser deposition of carbides and nitrides coatings” International Symposium Proceeding World Ceramic Congress and Forum on New Materials (1998) in press
 33. Ashok Kumar, “Pulsed laser deposition of superhard nitride coatings” Surface Modification Technologies XII, Edited by T. S. Sudarshan, K. A. Khor, and M. Jeandin, in press

(iii) Conference Presentations:

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2. U. Ekanayake, J. Sylvester, D. Kjendal, G. Wattuhewa and Ashok Kumar “Structural and mechanical properties of pulsed laser processed thin films and coatings “Ninth Annual Alabama Materials Research Conference, Birmingham 1995

3. H. L. Chan, Q. You and Ashok Kumar "Laser processing of superhard coatings" The University of South Alabama 3rd Annual Research Forum 1998
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5. L. A. W. Sanderson, J. J. Weimer, H. L. Chan and Ashok Kumar "Surface characterization of thin film hard coating" "Tenth Annual Alabama Materials Research Conference, Auburn 1998
6. Ashok Kumar, H. L. Chan, J. A. Barnard and N. B. Dahotre "Studies of mechanical properties of thin films prepared by laser ablation method, TMS Annual Meeting, Orlando (1997)
8. Ashok Kumar, J. J. Weimer, L. Sanderson and A. Weirzbicki "Surface characterization of hard coatings" TMS Annual Meeting, Orlando (1997)
9. Ashok Kumar, Q. You, I. Ahmed and A. Mangiaracina "Enhancement of nucleation density of HFCVD diamond films on silicon substrates with laser processed buffer layers" SPIE Proceeding, ROMOPTO 97, September 9-12, 1997, Bucharest (Romania)
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13. A. Mangiaracina, Ashok Kumar, I. Hussain, S. Perlaky and C. McCombs, "Novel approaches to enhance the binding of antigen-antibody with piezoelectric biosensor" Eleventh Annual Alabama Materials Research Conference, Huntsville 1997

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15. H. L. Chan, X. Yin, H. Rahman, A. Mangiaracina, and Ashok Kumar, "Laser processing and properties of nitride and carbide coatings" Eleventh Annual Alabama Materials Research Conference, Huntsville 1997
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17. Ashok Kumar and R. Bahl, "Growth, structure, and mechanical properties of pulsed laser deposited microlaminates coatings", MRS Fall Meeting 'Polycrystalline Thin Films – Processing-Structure-Property Relationship' 1998
18. R. Bahl, Ashok Kumar and M. Shamsuzzoha, "Synthesis of pulsed laser deposited gallium nitride films on sapphire substrates" MRS Fall Meeting 'Film Growth and Processing Using Hyperthermal Beams' 1998
19. Ashok Kumar, M. Galeev and M. Shamsuzzoha, "Effects of pretreated substrates on the growth morphology of diamond films prepared by hot filament chemical vapor deposition method" MRS Fall Meeting 'Properties and Processing of Vapor-Deposited Coatings' 1998

(iv) Invited Talk

1. The synthesis, characterization and mechanical properties of carbides and nitrides films prepared by pulsed laser deposition method, *Invited Talk*, Romopto 97, Bucharest (Romania)
2. Pulsed laser deposition of transition metal of carbides and nitrides coatings, *Invited Talk*, Ninth Cimtec- World Ceramic Congress & Forum on New Materials, 14th-19th June, Florence, Italy (1998)

**Advanced Materials Cluster
Alabama NASA-EPSCoR**

Annual Report: Year 5

Project: Simulation and Numerical Analysis in Support of Materials Processing
Coordinator: Dr. A. Kumar, University of South Alabama, Mobile

Research Objectives: To Develop a Numerical Model for the Pulsed Laser Ablation and Chemical Vapor Deposition Processes

(i) Mechanism of Laser-Induced Desorption and Ablation

Laser-induced desorption and ablation result from the conversion of an initial electronic or vibrational photoexcitation into kinetic energy of nuclear motion. Leading to the ejection of atoms, ions, molecules, and even clusters from a surface. In laser ablation process, design of processing experiment requires consideration of the coupling of the laser energy with target via the optical delivery system. There are several ablative mechanisms by which material, either atomic or bulk, can be released from the surface of the target. A computational model has been developed in order to simulate heat transfer with phase transition in laser ablation with or without the kinetics consideration. Front fixing method with Landau transformation has been used to represent the geometric domain. Energy absorption, heat transfer (1-D heat conduction), melting model and surface vaporization have been modeled to understand the ablation mechanism for simple system. Spectral collection method has been utilized for special discretization in this model, while backward differentiation techniques have been used for temporal discretization. A one-dimensional model has been compared with the experimental results but more work is needed to establish the 3-D model for multifunctional applications.

(ii) Simulation of Flow and Transport in CVD System

Diamond films on different substrates have considerable industrial importance, and hot filament assisted chemical vapor deposition has evolved as a promising method for this deposition process. In this study, the flow and temperature fields have been investigated numerically, in the absence of any chemical reaction, where a mixture of methane and hydrogen enters a cylindrical reactor maintained at a partial vacuum and gets heated by a hot filament. A finite-based commercial computational dynamics code has been used to provide the numerical simulations. Different filament geometries have been tested through these simulations. It has been found that a mesh filament is preferable to a conventional wire filament. Buoyancy has been found to play an important role, and radiative transport has been found to be significant in this computational model. It has also been found that any process optimization must involve several process parameters.

Publications:

1. Z. Wei, J. S. Kapat and Ashok Kumar "A computational Model for Simulation of Pulsed Laser Deposition Process" **Thin Solid Films** (in press)
2. G. B. Landsberg, J. S. Kapat, Ashok Kumar and I. Ahmed "Simulation of Diamond Film Deposition on Si Substrate using HFCVD Process" **Thin Solid Films** (in press)
3. J. S. Kapat, Z. Wei and Ashok Kumar "Role of Kinetics of Transformation in Pulsed Laser Ablation" **Applied Surface Science** , 4957 (1998)
4. Ashok Kumar, H. L. Chan and J. S. Kapat "Deposition and Characterization of Titanium Carbide Thin Films" **Applied Surface Science**, 5015 (1998)
5. I. Ahmed, Ashok Kumar, J. Kapat, A. Mangiracina and Y. Vohra "Effects of different filament geometries on the nucleation and growth of diamond films using the hot filament chemical vapor deposition method, *Journal of Applied Physics* (in press)

Thesis Supervision:

1. Z. Wei, "Numerical Simulation of Pulsed Laser Ablation Deposition Process" 1997-1999
2. U. Padungak, "Numerical Simulation of Diamond Deposition by Combustional Flame Assisted CVD Process" 1997-1999

Other Research and Development Grants

1. TVA “Laser Processed Superhard Coating for Tribological Applications” (\$27,696) 1994-1995
2. DOE EPSCoR Graduate Trainee Fellowship “Laser Patterning of Organic Semiconducting Materials” (\$18,142) 1994-1995
3. NSF Academic Research Infrastructure “ Acquisition of Scanning Electron Microscope and X-ray Diffractometer for Education and Research” (\$159,430) 1995-1998
4. USA Research Council “Ferroelectric Thin Films for Electronic Materials” (\$2,500) 1994-1995
5. NSF SIP “Smart Materials for Transport Control” (\$270,000) 1995-1998
6. DOE EPSCoR Young Investigator Award “ Wave-guide Structures on Organic Thin Films by Laser Patterning Method” (\$19,380) 1995-1997
7. NRC Twinning Fellowship Program “Growth and Characterization of Carbides/Nitrides Thin Films Prepared by Laser Processed Methods” (\$13,000) 1997-1999
8. NSF EPSCoR Young Investigator Award “Synthesis and Characterization of Pulsed Laser Ablated Biocompatible Thin Films” (\$44,452) 1997-1998
9. NSF : Novel Synthesis and Fabrication of Hybrid Nanostructured Coatings for Manufacturing Applications” (\$213,362) 1999-2003

Patents

1. Ashok Kumar and M. Galeev “ Diamond Growth on Si Nanoparticles embedded in Silicon Substrates” (under preparation)

Mentoring Work with Small College Contributors

Dr. G. Wattuhewa from Alabama School of Math and Science (ASMS) is associated with our research activity at the University of South Alabama. Dr. Wattuhewa is also

**Alabama NASA EPSCoR
1998-1999 Report**

Project PI

Dr. Michael A. George

Department of Chemistry

University of Alabama in Huntsville

1. Project Goals for Current Year

Goals for the current year included continued collaboration with Professor Ashok Kumar at USA in the characterization of pulsed-laser deposited films and the continued development of a chemical sensor research program involving Professor Kumar and other investigators. In addition to the films produced by Professor Kumar, we also began to investigate the preparation of nanoclusters of silicon carbide and silicon nitride by laser deposition methods. It is anticipated that a publication will result from this work.

The past year also resulted in the continued development of new projects that have a direct collaboration with NASA. These include the study of crystal growth and nucleation processes in collaboration with Drs. Alex Chernov and Ching-Hua Su at NASA Marshall Space Flight Center. We have submitted four publications from this collaboration with MSFC. Another project involving a collaboration between NASA Lewis, Alabama A&M University (a Historically Black College and University) and our group at UAH saw success in the study and development of elevated temperature silicon carbide chemical sensors. This study resulted in three publications and a patent disclosure.

2. Research Accomplishments

2.1. University of Alabama Huntsville-University of South Alabama Collaboration

In the area of the characterization of pulsed-laser deposited films and nanoclusters (PLD), we continued to examine the surface morphology and composition of wide band-gap semiconductor materials, primarily nitrides and carbides. A detailed study was performed on silicon carbide and silicon nitride powders produced by this technique.

2.2. University of Alabama Huntsville-NASA Marshall Space Flight Center Collaboration

This work involved the characterization of crystal growth processes and was performed on both Cr doped and undoped ZnSe crystals grown in a horizontal furnace and in a vertical furnace. The as-grown surfaces of the undoped horizontally grown crystals were dominated by (110) facets and steps, while the as-grown faces from the vertically grown crystals showed granular structures with tubular features on the surface. AFM characterization of the Cr doped ZnSe horizontally grown crystals showed (110) facets and steps similar to that for the undoped crystals. The Cr doped crystals grown vertically had a network of high plateau. Numerous nuclei with diameters of 20-50 nm and a height of 1-7 nm were also observed. Recent efforts have been to try to image the doped crystals employing a relatively new scanning probe technique, scanning capacitance microscopy, in order to correlate surface structure with dopant segregation under similar growth conditions. I hope to continue to collaborate with Dr. Su in the years to come on this project as well as a new project being planned to examine the effects of microgravity conditions on the nucleation and growth processes of silicon carbide.

A more recent collaboration has been initiated with Dr. Alex Chernov to study protein crystal growth characteristics using *in-situ* AFM techniques. In the last 8-12 weeks, we have begun to establish viable protocols to obtain reliable AFM images on protein crystal surfaces. We have been successful in obtaining AFM images of monatomic steps and terraces on lysozyme protein crystal surfaces. We are currently setting up an adiabatic chamber around the AFM to control the temperature of the protein

solution in order to control growth conditions. An objective is to be able to acquire repeated scans of selected regions in order to examine the real-time growth and translation of step structures. The participants in this work are Phillip McCarty, my graduate student, another visiting graduate student, Jose Gavira, and myself. Phillip would like to perform his Ph.D. research on microgravity crystal growth studies.

2.3 University of Alabama Huntsville-Alabama A&M-NASA Lewis Collaboration

This project involves the development of applications for silicon carbide epitaxial films prepared at the NASA Lewis Research Center and modified and characterized by our group and that of professor Daryush Ila at Alabama A&M University. We have been looking at the development of elevated temperature silicon carbide chemical sensors the past year. In this study, the (I-V) properties of the sensors were measured as a function of hydrogen, propylene, and methane exposure at elevated temperatures and sensor responses were observed for each gas. The response to hydrogen and propylene were found to have a rapid increase and leveling off of the current followed by the subsequent decrease to the baseline when the gas was switched off. However, exposure to methane resulted in a rapid spike in the current followed by a gradual increase with continued exposure. X-ray photoelectron (XPS) studies of methane exposed SiC sensors revealed that this behavior is attributed to the oxidation of methane at the Pd surface. This linear increase with exposure for methane was the first such response for methane reported in literature and is the subject of a patent disclosure for this sensor.

A second device application for elevated temperature silicon carbide sensors was to employ low-energy ion implantation techniques to implant metal nanoclusters at subsurface levels on the SiC. This preparation shows promise for a remote chemical sensor operated at temperatures in excess of 1400 °C. Using high dose, high-energy ion implantation followed by annealing at temperatures between 500 to 1500° C, we have formed nanoclusters of Au, Ag, Sn and Cu in Si-face 6H-SiC. In general, the implantation of metal ions into any photorefractive material followed by either thermal annealing or by post MeV bombardment of the implanted region leads to an increase in the optical absorption as well as an enhancement of the nonlinear optical properties. These effects are due to the formation of nano-metallic clusters with diameters less than 30 nm. Because high index of refraction of the SiC, we are able to detect the formation of Sn nanoclusters, simply by detecting formation of an optical absorption band at around 430 nm. For other photorefractive materials, such as Silica, MgO and LiNbO₃, this band falls in the low UV regions, near F-centers. In this paper, we will present the results we have obtained from keV to MeV implantation of ions, such as Au, Ag, Sn, and Cu into SiC. Using optical absorption spectrophotometry, Rutherford Backscattering Spectrometry (RBS), ion beam channeling, as well as by Transmission Electron Microscopy (TEM), we have correlated the theoretically predicted cluster size to its experimental values and explained the process mechanism.

NASA-EPSCoR Five Year Summary Report

Dr. Yogesh K. Vohra (UAB Coordinator)

Dr. John T. Tarvin, (Samford University)

- **Project Goals for the current year**

- (1) Large Area Diamond Deposition System.
- (2) Nano-diamond coating on titanium alloys - mechanical properties and tribological tests.

- **Research Accomplishments**

- (1) Large Area Diamond Deposition System: NASA-EPSCoR support has lead to the acquisition of a six kilowatt-microwave plasma chemical vapor deposition system. This system allows for diamond coating of a 4-inch diameter substrate. Resonant cavity is designed to operate in the TM_{013} mode to produce a uniform plasma density over the substrate. A new substrate design has been implemented which allows for stable temperature operation for twelve or more hours. This six kilowatt system is now operational at the University of Alabama at Birmingham (UAB) and several diamond growth experiments on metallic substrates as well as diamond on diamond experiments have been successfully carried out. Graduate student Marc Fries is working on the computer interfacing of this equipment using Lab view software.
- (2) Nano-diamond Coating on Titanium Alloys: In this support period, we have demonstrated a new growth regime for synthesis of nano-crystalline diamond films in high-density plasma. For a plasma operating at a pressure of 125 torr, with a relatively high concentration of methane (15 % CH_4 in hydrogen), small amount of nitrogen causes nanocrystalline film formation. Figure 1 shows the dramatic effect of nitrogen on the microstructure of diamond films. Crystalline diamond films have a rough surface with a root mean square (rms) roughness of 270 nm (Fig. 1). The crystalline diamond films will usually require post-growth polishing procedure for most applications. On the other hand, nano-crystalline diamond films are naturally smooth and have a rms roughness of only 27 nm (Fig. 1) and would not require any post-growth polishing procedure. There is also an increase in toughness exhibited by these nano-films as compared to the crystalline films as was demonstrated after an indentation by a Vickers indenter. Optimal deposition conditions have been found which yield films that are hard (hardness value of 92 GPa) and exhibit a low coefficient of friction (0,08). Future work will explore the mechanisms responsible for the nitrogen-induced nanocrystallinity.

- **Industrial Collaboration**
Zimmer Inc., Warsaw, Indiana
- **Collaboration with government agencies:**
Dr. Yogesh Vohra is a consultant to the Lawrence Livermore National Laboratory (DOE).
- Other funding requested
- **Journal Articles Published**
 - (1) Shane A. Catledge and Yogesh K. Vohra, "Effect of Nitrogen Addition on the Microstructure and Mechanical properties of Diamond Films Grown Using a High Density Plasma", submitted to Appl. Phys. Lett, January 1999.
 - (2) Shane A. Catledge and Yogesh K. Vohra, "High density Plasma Processing of Nanostructured Diamond Films on Metals", J. Appl. Phys. **84**, 6469 (1998).
 - (3) Shane A. Catledge, Walt Comer, and Yogesh K. Vohra, "In-situ Diagnostics of Film Thickness and Surface Roughness of Diamond Films on Ti-6Al-4V alloy by Optical Pyrometry, Appl. Phys. Lett. **73**, 181 (1998).
 - (4) Shane A. Catledge and Yogesh K. Vohra, "Mechanical properties and Quality of Diamond Films Synthesized on Ti-6Al-4V Alloy Using the Microwave Plasma of CH₄/O₂/H₂ and CO/H₂ systems, J. Appl. Phys. **83**, 198 (1998).
 - (5) Thomas S. McCauley, Andrew Israel, Yogesh K. Vohra, John T. Tarvin, "Spatially resolved In-situ Diagnostics for Plasma Enhanced Chemical Vapor Deposition Film Growth", Rev. Sci. Instrum. **68**, 1860 (1997).
 - (6) Shane A. Catledge and Yogesh K. Vohra, "High Density Plasma processing of Diamond Films on Titanium: Residual Stress and Adhesion Measurements", J. Appl. Phys. **78**, 7053 (1995).
 - (7) T. S. McCauley and Yogesh K. Vohra, "Homoepitaxial Diamond Film Deposition on a Brilliant Cut Diamond Anvil", Appl. Phys. Lett. **66**, 1486 (1995).
 - (8) J. Liu, Yogesh K. Vohra, J. T. tarvin, S. S. Vagarali, "Cubic-to-rhombohedral Transformation in Boron Nitride Induced by Laser Heating", Physical Review B **51**, 8591 (1995).
- **Conference Papers Published (refereed)**
 - (1) Shane A. Catledge and Yogesh K. Vohra, "Nitrogen-Induced Nanocrystallinity of CVD Diamond Films on Ti-6Al-4V Alloys", to be published in the proceedings of Materials Research Society, Fall 98.
 - (2) Shane A. Catledge and Yogesh K. Vohra, "Structure and Stress Evaluation of Diamond Films Deposited on Ti-6Al-4V Alloy at low temperature Using CH₄/O₂/H₂ and Co/H₂ Gas Mixtures", Mat. Res. Soc. Symp. Proc. Vol. **505**, 629 (1998).
 - (3) Shane A. Catledge, Yogesh K. Vohra, Chih-Shiue Yan, and H. T. Tohver, Morphology and Quantitative Nitrogen Impurity Measurements in Homoepitaxial Chemical Vapor Deposited Diamond", Mat. Res. Soc. Symp. Proc. Vol. **441**, 635 (1997).

- (4) Thomas S. McCauley and Yogesh K. Vohra, "High Temperature Diamond Film deposition on a Natural Diamond Anvil", in *Applications of Diamond Films and Related Materials: Third International Conference, 1995* Editors, A. Feldman, Y. Tzeng, W. A. Yarbrough, M. Yoshikawa, and M. Murakawa, NIST special publication 885, page 377.
- (5) Thomas S. McCauley and Yogesh K. Vohra, "Defects and Morphology of Homoepitaxial Diamond Films on Natural Nonplanar and Isotopically Pure Planar Substrates", *Mat. Res. Soc. Symp. Proc. Vol. 416*, 63 (1996).
- (6) Thomas S. McCauley, and Yogesh K. Vohra, "Low temperature Micro-Photoluminescence of Defect Centers in CVD Diamond Films", in *Advances in New Diamond Science and Technology*, Fourth International Conference on New Diamond Science and Technology, editors S. Saito, N. Fujimori, O. Fukunaga, M. Kamo, K. Kobashi, and M. Yoshikawa, MY Tokyo, 1994, page 371.

- **Papers Presented at Meetings**

- (1) Andrew Israel and Yogesh K. Vohra, "Growth of Single Crystal Diamond at High Pressures by Microwave Plasma Assisted Chemical Vapor Deposition, 11th Annual Materials Research Conference, Sept. 25-26, 1997, University of Alabama in Huntsville.
- (2) Shane A. Catledge and Yogesh K. Vohra, "Mechanical and Tribological Properties of nano-structured Diamond Films on Ti-6Al-4V Substrates" Transactions of Metallurgical Society (TMS) meeting (February 28 - March 4, 1999), Symposium on Surface Engineering: Science and Technology I, 1999.

- **PhD dissertations and MS Thesis**

- (1) Thomas Greene McCauley, Ph.D. dissertation entitled "Synthesis and Characterization of Metastable Phases of Carbon", The University of Alabama at Birmingham, 1996.
- (2) Andrew Israel, Masters Thesis entitled "A Detailed Investigation Of Microwave Plasma-Assisted Chemical Vapor Deposition Growth Parameters", The University of Alabama at Birmingham", 1998.
- (3) Shane A, Catledge, Ph.D. dissertation entitled "Synthesis of Diamond Thin Films on Ti-6Al-4V Alloy: Residual Stress and Mechanical Properties". The University of Alabama at Birmingham, 1999.

- **Patents awarded or pending**

- (1) Y. K. Vohra and T. S. McCauley, **US Patent on Diamond Issued in 1997 -- Patent Number 5,628,824: "High Growth Rate Homoepitaxial Diamond Film Deposition at High Temperatures by Microwave Plasma Assisted Chemical Vapor Deposition"**.
- (2) Y. K. Vohra and S. A. Catledge, **US Patent on Nano-Diamond Filed in October 1998, "A Process for Ultra Smooth Diamond Coating on Metals", D6176.**



METALLURGICAL AND MATERIALS
ENGINEERING DEPARTMENT

THE UNIVERSITY OF ALABAMA
College of Engineering

March 19, 1999

Dr. Richard Comfort
Associate Director
Alabama NASA EPSCoR
Alabama Space Grant Consortium
EB 136-L
The University of Alabama in Huntsville
Huntsville, AL 35899

Dear Dr. Comfort:

Enclosed please find the Year 5 Annual Report for the Alabama NASA EPSCoR project. As discussed previously, the comprehensive report for the entire five years is forthcoming.

Sincerely,

Viola L. Acoff, Ph.D.
Assistant Professor

cc: Dr. Kumar, USA
Pam Standifer, OSP-UA

**ENHANCED MATERIALS PERFORMANCE THROUGH ENGINEERED INTERFACE
AND SURFACE MODIFICATION**

Alabama NASA EPSCoR

**Year 5 Annual Report
March 1999**

Project 3: Microstructure and Mechanical Properties of Microlaminates

**Viola L.Acoff
Assistant Professor
Department of Metallurgical & Materials Engineering
The University of Alabama
Tuscaloosa, AL 35487-0202**

phone: 205-348-3761
fax: 205-348-2164
email: vacoff@coe.eng.ua.edu

ALABAMA NASA EPSCoR - Year 5 Annual Report - March 1999

Project 3: Microstructure and Mechanical Properties of Microlaminates

Viola L. Acoff; Department of Metallurgical & Materials Engineering, The University of Alabama

Current Status:

This project currently supports the work of Mr. Jian-Guo Luo, a Ph.D. student in the Department of Metallurgical & Materials Engineering. Unfortunately, Stillman College has decided to withdraw from this program. Thus, we did not have any participation from any of their students during Year 5. Mr. Luo's work has focused on the development of reaction sequences to achieve a complete reaction between the titanium and aluminum foils to produce the intermetallic compound TiAl. The initial results of this project was used to submit two proposals to two different federal agencies: the Office of Naval Research and the Air Force Office of Scientific Research. Both proposals were not funded, however, we have recently received very positive responses to and significant interest in the project from peers and industry. The current data and other information that was determined during Year 5 of this project will be used to revise the proposal and resubmit it to the National Science Foundation in April 1999.

In Year 5, the following paper was accepted for publication in a refereed conference proceedings:

J-G. Luo and V.L. Acoff, "Gamma Titanium Aluminide Developed by Interdiffusion of Multi-Laminated Titanium and Aluminum," accepted, *Gamma Titanium Aluminides 1999*, TMS

This paper was also presented by Mr. Luo at the 1999 TMS Annual Meeting in March 1999 held in San Diego, California. Mr. Luo's presentation won first place in the *Gamma Titanium Aluminides Symposium*.

Future Work:

We will use the nanoindentation instrument to determine the mechanical properties of the microlaminates. Goals for the current year are:

- 1) Determine mechanisms to eliminate void formation in the microlaminates.
- 2) Use alloyed foils to improve mechanical properties.
- 3) Develop an expression for the diffusion of titanium and aluminum in multiple- stage lamination.

Participant Information:

Faculty (UA)

Graduate Student (UA)

Viola L. Acoff

Jian-Guo Luo

Black female

Asian male

**NOVEL PROCESSES AND APPLICATIONS OF CVD DIAMOND
AND CUBIC BORON NITRIDE FILMS**

YEAR-5 REPORT

**FOR THE PERIOD
JUNE 1, 1998 – MAY 31, 1999**

SUBMITTED TO

**DR. RICHARD H. COMFORT
' ASSOCIATE DIRECTOR
ALABAMA NASA EPSCoR
CSPAR, EB136L
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE, ALABAMA 35899**

FOR

**PROJECT #2
OF
ALABAMA NASA EPSCoR GRANT**

BY

**DR. YONHUA TZENG
PROFESSOR
DEPARTMENT OF ELECTRICAL ENGINEERING
AUBURN UNIVERSITY
AUBURN, AL 36849
TEL: (334) 844-2427
FAX: (334) 844-2433**

MARCH 15, 1999

oxygen or carbon dioxide supplied from high-pressure gas cylinders was used for the diamond deposition.

The manufacturing costs for diamond can be greatly reduced if the feedstock for diamond deposition is in the form of some kind of inexpensive liquid solutions. This will be especially useful if diamond can be deposited by both plasma enhanced chemical vapor deposition techniques as well as non-plasma processes, i.e. the hot-filament chemical vapor deposition technique.

During the fifth year, two diamond deposition processes have been invented using only liquid solutions as the feedstock. They are methanol-based microwave plasma enhanced diamond deposition process and the methanol-based hot-filament assisted diamond deposition process. Diamond of high quality can now be deposited on silicon, molybdenum, copper, aluminum, and many other substrate materials without using any compressed gas. Two provisional patent applications have been filed for these new diamond deposition processes.

3. Inventions and Publications

A. Inventions

- (1) Y. Tzeng and H. B. Zhu, "Method of Synthesizing Cubic Boron Nitride," US Patent pending.
- (2) Y. Tzeng, "Methanol-based Microwave Plasma Enhanced Diamond Deposition Process," US Provisional Patent Application filed in February 1999.
- (3) Y. Tzeng, "Methanol-based Hot-filament Assisted Diamond Deposition Process," US Provisional Patent Application filed in February 1999.

B. Publications

- (1) Y. Tzeng, "Methanol-based Microwave Plasma Enhanced Diamond Deposition Process," to be presented in the ADC/FCT '99, August 31, 1999, Japan.
- (2) Y. Tzeng, "Methanol-based Hot-filament Assisted Diamond Deposition Process," to be presented in the ADC/FCT '99, August 31, 1999, Japan.
- (3) Y. Tzeng and H. B. Zhu, "Electron Assisted Deposition of Cubic Boron Nitride by RF Magnetron Sputtering," Presented in the 6th International Conference on New Diamond Science and Technology, August 30, 1998, South Africa, and accepted for publication in the Diamond and Related Materials journal, 1999.

- (4) T.H. Chein and Y. Tzeng, "Deposition of Diamond by Microwave Plasma in Acetone/ Oxygen and Acetone/ Carbon Dioxide Mixtures," Presented in the 6th International Conference on New Diamond Science and Technology, August 30, 1998, South Africa, and accepted for publication in the Diamond and Related Materials journal, 1999.
- (5) T.H. Chein, J. Wei, and Y. Tzeng, "Microwave Plasma Enhanced Deposition of Diamond at Elevated Substrate Temperatures," Presented in the 6th International Conference on New Diamond Science and Technology, August 30, 1998, South Africa, and accepted for publication in the Diamond and Related Materials journal, 1999.

Collaboration

- (1) 3M Co. in St. Paul Minnesota: Consulting services on diamond and cBN technologies and applications.
- (2) University of Alabama in Birmingham: Dr. Tzeng serves as a member of Ph.D. Dissertation Committee for two of Dr. Vohra's students (one has graduated). Dr. Tzeng travels to Birmingham to participate in meetings with these graduate students and to use the Raman spectroscopy system in Dr. Vohra's Lab.

Participants

Faculty:	Yonhua Tzeng	Male
Engineer:	Calvin Cutshaw	Male
Graduate Students:	Liu Chao M.S. student in Electrical Eng.	Male
Undergraduate Student:	Michael Whitney	Male

Other Research Funds

Y. Tzeng (Principal Investigator) "Plasma and Laser Assisted Manufacturing Technologies," \$40,000, October 1, 1998 – September 30, 1999, Alabama Microelectronics Science and Technology Center.

Y. Tzeng (Principal Investigator) "Wide-bandgap Semiconductor Coatings for Cold Cathode Applications," \$390,000, May 1, 1998 – April 30, 2001, US Navy.

APPENDIX B:
Annual Reports
Remote Sensing Cluster

NASA EPSCoR

UNIVERSITY OF ALABAMA IN HUNTSVILLE
SUBGRANT (SUB97-054)

Athens State University

Annual Progress Report
March 15, 1999

Project goals: Athens State University (ASU) goals for the fifth year of the NASA/EPSCoR grant have been to apply GPS/GIS technology to locate habitat for sensitive species, and to establish a GPS/GIS laboratory at ASU. The investigator has employed GPS technology to map a large cedar glade in Lawrence County, AL and, applying both supervised and unsupervised multispectral classification methods to LANDSAT data, has achieved limited success to produce output that shows the location of cedar glades with a reasonable level of precision. Further, the ASU has determined to locate a GPS/GIS laboratory on its campus in Naylor Hall.

Research accomplishments: In an attempt to isolate a spectral signature for cedar glade habitat, the investigator has used GPS technology to establish coordinates for points within the largest intact cedar glade in north Alabama, namely Prairie Grove Glade. This glade is habitat for a community of rare or uncommon vascular plants, including *Dalea foliosa* (leafy prairie clover), a federally endangered species. The output is scaled so that areas identified as cedar glades are assigned a color or number to indicate likelihood for its actually being a cedar glade. Areas so identified will be ground truthed April-May 1999, thereby establishing cedar glades to investigate for the presence of sensitive plant species. To accommodate a GPS/GIS laboratory, ASU will undertake limited renovation of Naylor Hall, and outfit the laboratory, during the period June-August 1999. The lab will be equipped with four state-of-the art computer workstations, and will be supported by ERDAS Imagine and ESRI ArcView software. A fourth computer system housed in the lab will be dedicated as a GeoLink base logger.

Other accomplishments: None.

Student involvement: Dr. Jandebour has involved two students to assist his effort to employ GPS/GIS technology to locate cedar glade habitat in north Alabama: Mandy Cooper, a recent graduate of Auburn University's School of Forestry, and Pat Smith, a master's student at Auburn University's School of Forestry.

Collaborations with other scientists: Dr. Jandebour attended the Annual Meeting of the Remote Sensing Cluster held October, 1998 at Samford University, Birmingham, AL. Regarding research in progress and items of interest to the Cluster, Dr. Jandebour periodically is updated by members of the Cluster at Jacksonville State University, Jacksonville, AL.

Industrial collaborations: None.

Collaborations with government agencies: Dr. Jandebeur has developed some interest on part of the U. S. Fish and Wildlife Service regarding application of remote sensing technology to manage sensitive species.

Other funding requested: None.

Journal articles submitted: None.

Papers submitted to or presented to meetings:

“Application of remote sensing technology to locate cedar glade habitat in north Alabama: a preliminary report.” Tom Jandebeur, Mandy Cooper, and Pat Smith. Paper presented before the Geography, Forestry, Conservation, and Planning section of the Alabama Academy of Science at its 76th Annual Meeting, held at Athens State University March 24-27, 1999.

Abstract: Using GPS/GIS and multispectral image classification techniques, the objective of this investigation is to locate cedar glade habitat in north Alabama using a LANDSAT image, thereby establishing additional locations to investigate for the presence of sensitive plant species. Our investigation focuses on Prairie Grove Glade, located in Lawrence County, AL, habitat for a community of rare or uncommon vascular plants, including *Dalea foliosa*, a federally endangered species.



MILES COLLEGE

P.O. BOX 3800
BIRMINGHAM, ALABAMA 35208

Division of Natural
Sciences and Mathematics

March 15, 1999

Dr. Richard H. Comfort
NASA/EPSCoR Project
Alabama Space Grant Consortium
The University of Alabama in Huntsville
Huntsville, AL 35899

RE: Year 5 Annual Report

Dear Dr. Comfort:

The following paragraphs will serve as the annual report for the Miles College participants in the NASA/EPSCoR project. A brief synopsis of the planned and completed activities will be presented.

Also, I have enclosed an expenditure sheet. If you have any questions, please call (205) 929-1552 or by email ccwwaw@aol.com.

Sincerely,

Charles C. Woods
NASA/EPSCoR P.I.

cc: Dr. Leotis Williams
Mr. George French
Dr. George Clines

NASA/EPSCoR ANNUAL REPORT

**Annual Report
March 15, 1999**

**Charles C. Woods, Ph.D.
Associate Professor
Division of Natural Sciences and Mathematics
Miles College
Birmingham, Alabama 35208
Tel: (205) 929-1552
Fax: (205) 929-1550
email: ccwwaw@aol.com**

Project goals for the current year

In year 5, emphasis will be placed on habitat investigations. The types of habitats of interest involved watersheds in the Birmingham and surrounding area. With the recent Village Creek investigation, students have become fascinated with water quality as it relates to overall ecosystem stability. In year 5, EPSCoR scholar will be involved with water shed quality. In addition, students will continue to familiarize themselves with the use of Global Positioning Systems (GPS) to help locate points of interest. To assist with this endeavor, two portable GPS units have been purchased.

There will also be a comprehensive involvement in science education and research training. This will accomplished in the form of curriculum development and K-12 involvement form the Birmingham Public School System. This involvement hopes to define research projects that can be conducted and information taken back to the young investigator school of origin during the academic year.

Research Accomplishments

The Village Creek research conducted directly addresses an important area of interest in the process of identifying and quantifying water quality characteristics that are of interest to the Birmingham and surrounding area. The data generated from this research was inconclusive; therefore, research and data are being documented. The ultimate goal of this evaluation is the development of a reasonable description of the given reservoir. This description can then be used to evaluate the effectiveness of remediation and recovery of alleged contaminants as well as the impact of loss of diversity.

Student Involvement

There were not any NASA/EPSCoR scholars identified during the fall semester. In early spring, we will select individuals to participate in the program. I have been able to utilize students participating in the PEJER project to continue research started by EPSCoR scholars who was lost due to graduation. Currently, we have two former NASA/EPSCoR scholar attending Alabama A&M University. Joseph Dennis is working closely with Dr. Tommy Coleman as he pursues an advance degree in Environmental Chemistry. Aaron Jeffries is pursuing an advance degree in molecular biology and genetic engineering with environmental applications.

Konard Yancie, Senior, Environmental Science major will become the first graduate from this program during the spring 1999 semester. In addition to being a scholar, he also was a starting member of the Golden Bear Football team (see attachment 1).

Roderick Brown, Junior, Environmental Science major was the recipient of the Malcolm Pirnie Scholarship. He was one of six students chosen from a nationwide applicant pool. (See attachment 2). He served as an intern in the Birmingham office during the summer of 1998. During the fall of 1998, Roderick was offered a staff position by Malcolm Pirnie as he finishes his degree.

Student Participants	Status
Konard Yancie (1998)	Senior
Roderick Brown (1998)	Junior

Sonceria Coleman (1998)	Sophomore
Lorraine Brown (19980	Graduate
Joseph Dennis (1997)	M.S/Ph.D. Program Alabama A&M University
Aaron Jeffries (1997)	M.S./Ph.D. Program Alabama A&M University
Otis Taylor (1997)	M.D/Ph.D. Program Hampton University
Lucretia Jones (1997)	M.S/Ph.D. Program Mississippi State University
McKeel Richardson (1996)	Senior
Alfreda Childress (1995)	Senior Transferred to UAB .

Collaborative Activity

The environmental science program has witnessed an increase in the number of students wanting to become involved in environmental issues. There is discussion about the necessity employ additional faculty to meet this demand. In addition, Miles College has been involved in discussions with other school in the area, University of Alabama at Birmingham (UAB), The University of Montevallo, Samford University (SU), and Birmingham Southern College (BSC), concerning course offering through an existing agreement that would allow students to select courses from the neighboring institutions that would strengthen their knowledge in the area of environmental science. Miles College is in a unique position, of the schools listed above, only Miles College and Samford University offer a major in environmental science. In addition, Miles College offers two courses that are pertinent to environmental science majors that are not offered at the other institutions. Therefore, from a financial standpoint, the new major in environmental science should prove beneficial.

Miles College - Alabama A&M University. During year 2 of the project, the PI has traveled to Normal Alabama to seek hands-on experience with Remote Sensing/GIS Technology.

Miles College - Jacksonville State University. In a continual effort to foster the aims of the project, I have had the opportunity to collaborate with Dr. George Cline at Jacksonville State University via E-mail and phone conversations.

Miles College - University of West Alabama. Meaningful collaboration between the project director and this university has commenced. West Alabama has one of the most established Environmental Science programs in the state. The project director has met with the coordinator of the internship phase of the program to gain insight into the placement of students at various facilities, fund raising and public and private companies' involvement.

Miles College - Oak Ridge National Laboratory (ORNL). ORNL has invited the project director of to submit a proposal to address environmental degradation. Miles College will then have the opportunity to become a part of a consortium that is designed to foster meaningful research and collaboration.

Miles College - Birmingham Water Works. There is a long-standing relationship between Miles College and the Birmingham Water Works. This relationship should prove valuable in the future when it comes to student research ventures.

Miles College and the Cahaba River Society (CRS). This relationship should prove valuable as we gain momentum in year two and beyond.

Miles College and the BACHE consortium (Birmingham Southern College, Samford University, The University of Alabama at Birmingham, The university of Montevallo) Discussions have commenced concerning the offering of additional environmental science courses through the existing BACHE agreement.

Miles College and the Environmental Clearinghouse have developed collaboration to foster environmental awareness in the diverse community. Miles College can benefit from the technology transfer because of the NASA/EPSCoR project.

Miles College and the Marine Environmental Science Consortium at Dauphin Island, Sea Lab.-We have entered into discussion with this agency in an attempt to provide internship opportunities for students.

Proposals Funded

Woods, Charles, C. 1998. The College Fund/Second Nature, Building Environmental Stewardship (BES). \$50,000.00

Future Work

As we embark upon year 5 of the project, there will be more comprehensive involvement of students. Moreover, Miles College is in the process of renovating existing facilities to enable a more comprehensive on campus research program. In addition, the college has installed a "state of the art" communication system that will serve as a link between Miles and collaborative institutions.

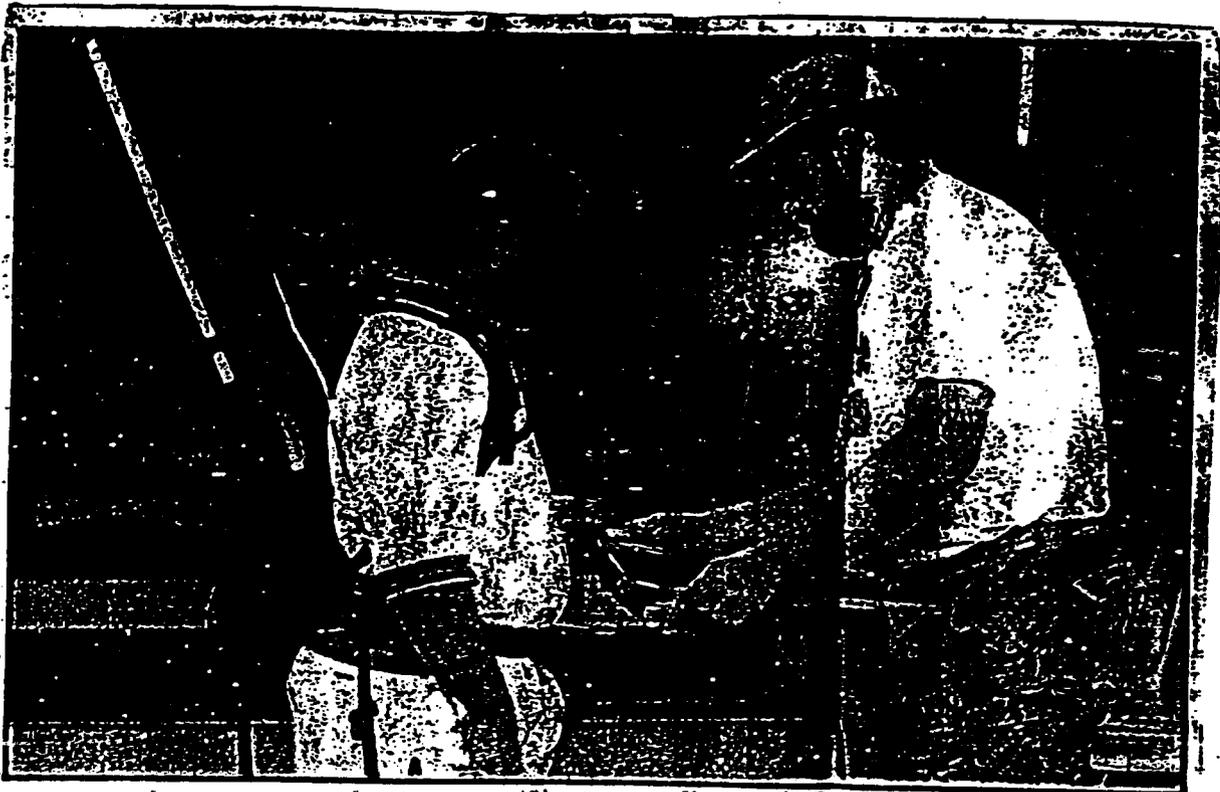
Provided funding is available, there are several other projects that have been identified by the investigator. One area is the growing concern dealing with Brownfields. Secondly, a survey of the watersheds in the Birmingham and surrounding area will prove valuable to the growing population. Biocide runoff from golf courses is an area that many people haven't considered. We will like to take an initiative and become involved in research in this area because it can have a profound effect on water quality. Storm water runoff and flood controls are also areas of interest. As you can see, this program has many goals and wants to expand to include many facets of research.

Conclusion

Miles College pledges to help the NASA/EPSCoR project in completing the goals of the project.

The Anniston Star

August 21, 1996



Richard Coe/The Anniston Star

Frank Romano, right, hooks up student Meekel Richardson with a Global Positioning System locator.

(Miles College)

NASA REMOTE SENSING CLUSTER / JSU

The group's efforts have revolved around four areas. The first group has been analyzing plant community structure based on field collections made between 1994-1997. The methodology to do this is a new application of a form of correlation analysis. The results of these analyses will be ready for submission in May. The on ground analysis has gone very well. The technique is very sensitive to differences among communities. We have been able to get GPS data for some of the missing sites, and Victor Wu has provided spectral analysis of several of the points. I (George Cline) have been focusing on a series of sites from Fort McClellan, Alabama. These data will be presented at the Alabama Academy of Sciences meeting the end of March, and these data form the bulk of a paper introducing the community analysis.

The second area of concentration has been collecting water quality data from the Coosa River during satellite flyovers. Frank Romano, Safaa Al-Hamdani, Gary Durrant, and graduate students Kirby Swenson and Brent Nichols have collected water quality data (focusing on turbidity and chlorophyll content) at 6 localities (3 in the Coosa and 3 in the adjacent tributaries) along the Coosa River. Frank reported on the preliminary results at the Alabama Academy of Sciences meetings in last year. This year they present further analysis of the turbidity data, and an analysis of chlorophyll content (correlated with phytoplankton concentrations) at the six study sites.

The third area of interest has focused on land-based analysis of reflected light using a portable spectroradiometer. Drs. Al-Hamdani and Durrant, and graduate student Brent Nichols, have been leading students into the field to collect data on light reflected off selected plant species on Dugger Mountain. These data were collected throughout the year to test for seasonal changes in reflectance. This data will be presented at the Association of Southeastern Biologists meetings in North Carolina in April, and they form the bulk of a paper that will be submitted in May.

Dr. David Whetstone, assisted by graduate students Althea Thompson, Kristin Brodeur, Hayes Jackson, and Steve Threlkeld, sampled lowland plant communities at 37 GPS located sites along the Coosa River drainage. Community characteristics were quantified using standard plant vegetation techniques. These data were entered onto the computer and await multivariate analyses in May. Wetland community types will be classified using standard wetland nomenclature. These sites will then be used to assess the availability of the various community types throughout the middle Coosa River Drainage.

Dr. Tom Baucom continues working on an analysis of urban/suburban development along AL Hwy 431 between Anniston and Gadsden over the last 20 years. He has used a combination of Landsat, SPOT, and high altitude photographic images to collect his data. Dr. Baucom's former assistant in this project, Mr. Patrick Francis, is currently in graduate school at Mississippi State University getting his MS in Geography. Mr. Francis is slated to be hired at JSU as a GIS technician and lecturer in the Department of Physical and Earth Sciences.

Indicators of Activity (Tracking and Metrics)

1. George Cline and Gary Durrant - organized Fall Remote Sensing Cluster meeting at Samford University, Birmingham AL. Oct. '98

2. Roger Sauterer - presented material on protein crystal growth for the Alabama Aerospace Teachers' Association Workshop on "Protein Crystal Growth". Teachers attending the workshop, and their students, will crystallize proteins in their classroom, and compare the results with crystals grown in microgravity. This mission is scheduled to fly in either August or October 1999. Workshop 20 Feb. 1999.

3. George Cline and Tim Huddleston (exec. Dir. Alabama Aerospace Teachers' Assoc.) are organizing a workshop for students entitled "Spaceship JSU". To celebrate Space Day, 6 May 1999, JSU faculty from Biology (Cline, Durrant, Romano), Physical and Earth Sciences (Rokke, Weinkauf, Gregg) will present a series of 6 programs for students including a planetarium show, visit to the JSU observatory, and a GPS session. Additional sessions might include mapping the moon, and a history of NASA. Each session can hold up to 25 students.

G. Equipment purchases & acquisitions

PROTEIN CRYSTAL GROWTH WORKSHOP
FEBRUARY 20, 1999

ATTENDEES

1. Dave LaFond Weaver, AL
2. Doreen Forsythe Huntsville, AL
3. Ronald Yates Andalusia, AL
4. Tamara Peppers New Market, AL
5. June Jackson Hokes Bluff, AL
6. Suzette Ford Hokes Bluff, AL
7. Mary Richardson Jasper, AL
8. Sandy Armstrong Abbeville, AL
9. Barry Wiginton Russellville, AL
10. Cheryl Smith Muscle Shoals, AL
11. Steve Ruiz Wetumpka, AL
12. Oscar Henderson Birmingham, AL

ANNUAL PROGRESS REPORT

Evaluation of Multispectral Imagery for Assessing Vegetation Characteristics and Soil Loss in Northern Alabama

Alabama A&M University

Project Goals:

The original project goals pertaining to our activity were completed last year with the graduation of Mr. Donville L. Williams. Mr. Williams is now employed with the U S Environmental Protection Agency (EPA) in Athens GA. In our continuing effort to pursue research in this area, other activities were initiated under the Center for Hydrology, Soil Climatology, and Remote Sensing (HSCaRS) related to the remote sensing cluster objectives. These include:

1. **Assessment of Soil and Vegetation Conditions Using Hyperspectral Data, GIS, and GPS Technology.** The primary objective was to develop adequate techniques to monitor and predict excessive phosphorus (P) levels and manage nitrogen (N) stress in cotton to preserve environmental quality and natural resource sustainability.
2. **Vegetation Classification and Characteristics Assessment Using *In Situ* and Remote Sensing Techniques for Soil Moisture Estimation and Hydrologic Modeling.** The primary objective of this work is to obtain measurements of the vegetation leaf area index (LAI), biomass, water content, phenological stage, and aerodynamic roughness, the fraction of absorbed photosynthetically active radiation (PAR) for input in hydrological models to study soil moisture and erosion transport of pollutants.
3. **Assessment of Water Quality and Sediment Transport Using Remote Sensing and GIS Based Models in Northern Alabama.** The primary objectives of this research are to examine the potential application of remote sensing to identify high sediment transport and deposit areas and to validate the soil erosion and sediment transport model on different forest management practices.

Research Accomplishments:

The research project involving the assessment of soil and vegetation conditions using hyperspectral data, GIS, and GPS technology was completed during this past year. Mr. Johnny L. Boggs, who conducted the study as partial fulfillment of his Master's Thesis requirements, successfully defended his work and was granted a Master's of Science Degree in July 1998. The results from this work inferred that hyperspectral data could be used to determine the amount of nitrogen concentration in the soil and predict crop yield through leaf chlorophyll concentration. Additionally, the data can also be used to detect nitrogen stress at site specific locations to optimize the application of nitrogen fertilizer.

Intensive data analyses of the other two research activities are ongoing. The study entitled "Assessment of Water Quality and Sediment Transport Using Remote Sensing and GIS Based Models in Northern Alabama" is led by Mr. Wubishet Tadesse as partial fulfillment of the requirements for his Ph.D. degree. Dr. Ahmed Fahsi is the lead scientist for the study entitled "Vegetation Classification and Characteristics Assessment Using *In Situ* and Remote Sensing Techniques for Soil Moisture Estimation and Hydrologic Modeling." Our goal is to complete these activities by May 2000.

Activity Participant Information:

Faculty

Dr. Ahmed Fahsi	Co-Pi	Male
Dr. Andrew Manu	Co-Pi	Male
Dr. Narayne Rajbhandari	Co-PI	Male
Dr. Tommy Coleman	Co-PI	Male

Graduate Students

Mr. Johnny L. Boggs	MS	Male
Mr. Wubishet Tadesse	Ph.D.	Male

Technician

Mr. Harold Anthony		Male
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Publications Refereed Journals:

Boggs, J., T. D. Tesgaye, A. Fahsi, and C. Reddy. 1998. Relationship between cotton leaf nitrogen and soil nitrate content under poultry litter plots. *Remote Sensing of Environment*. (Submitted February, 1998)

Fahsi, A., T. D. Tsegaye, T. L. Coleman, and W. Tadesse. 1998. Incorporation of DEM ancillary data with Landsat-TM data to improve landcover classification accuracy. *Elsevier's Forest Ecology and Management Journal*. (Submitted July 1998)

Hung, C.-C., A. Fahsi, and T. L. Coleman. 1999. Image classification. In J. G. Webster (ed.). *Wiley Encyclopedia of Electrical and Electronics Engineering*. John Wiley and Sons Publisher, New York, NY. (In Press)

Manu A., T. L. Thurow, A. S. R. Juo, and I. Zanguina. 1999. Integrated watershed management. *Journal of Soil and Water Conservation*. (In Press)

Rajbhandari, N. B., J. D. Gregory, C. Franklin, and J. E. Parsons. 1999. Effects of flow dispersal in forested filter zones. *Journal of the American Water Resources Association*. (Submitted November 1998)

Date Submitted	Agency	Principal* and Co-Investigator**	Program and Title of Proposal	Years	Total	Status
8/8/97	USDoI- BLM	T. Coleman* G. DaBai** A. Fahsi**	Minority Faculty GIS/RS Applications Workshop	1	\$5,000	Pending
9/13/98	NASA	T. Tsegaye* B. G-Gwahid** N. Rajbhandari** W. Tadesse**	NRA-98-OES-11: Watershed Hydrology as Predicted by Site-Specific Soil Properties, Vegetation Parameters, and Meteorological Inputs Using a Remote Sensing/GIS Approach		Pre-Proposal	Declined
9/4/98	NASA	T. Tsegaye* B. G-Gwahid** W. Tadesse**	NRA-98-OES-09: Integrated Remote Sensing Initiative on Agriculture to Assess Water Stress Conditions on Plants	3	\$547,307	Pending
9/4/98	NASA	A. Fahsi** T. Tsegaye** T. Coleman** A. Manu C. Martin**	NRA-98-OES-09: Development of Remote Sensing Protocols for Monitoring and Assessing Terrestrial Ecosystems	3	\$593,440	Pending
9/4/98	NASA	N. Rajbhandari* T. Coleman** A. Fahsi** T. Tsegaye**	NRA-98-OES-09: Development of Overland Flow Roughness Coefficient for Forested Watersheds Using the Airborne Visible-Infrared Imaging Spectrometer Data	3	\$430,000	Pending

8/1/97	US Army	T. Tsegaye* T. Coleman** R. Taylor** G. Sharma**	Providing Research Services in the Area of Army Land and Natural Resources Impact Assessment: Ecosystem and Simulation Modeling	5	\$6,000,000	Pending
9/2/98	USDoI	T. Coleman** T. Tsegaye** A. Fahsi** N. Rajbhandari**	Unsolicited - National Imagery and Mapping Agency: GIS and Remote Sensing Curriculum Enhancement at Alabama A&M University	3	\$107,239	Pending
2/25/99	USDA	A. Manu* C. Beyl** C. Reddy**	Higher Education Multicultural Scholars Program: Enhancement of Minority Participation in Plant and Environmental Science Training	4	\$100,00	Pending
3/26/99	USDA	K. Sistani* D. Mays** A. Fahsi**	Capacity Building Grants: Environmental Impact of Land Applied Animal Waste: Biogeochemistry and Using Remote Sensing and GIS.	2	\$217,966	Pending
3/29/99	ADEM	N. Rajbhandari* A. Fahsi** P. Cannon**	Alabama Clean Water ACT Section 319(h): Identification of Critical Streams in the Flint River Watershed Using a Non-Point Source Model Geographic Information System (GIS) and Remote Sensing	3	\$125,280	Pending



HOWARD COLLEGE OF ARTS AND SCIENCES
Department of Geography

March 23, 1998

Dr. Hugh Comfort
Associate Director
Alabama NASA EPSCoR Project
CSPAR, EB136L
The University of Alabama in Huntsville
Huntsville, AL 35899

Alabama NASA EPSCoR 1999 Institution Progress Report
Department of Geography, Samford University

The following represents a summary of activities on the part of Samford University as a participant in the Alabama NASA EPSCoR Grant. Samford University is one of five Alabama colleges and universities working in consortium to investigate the effectiveness of using remotely sensed imagery to indicated vegetation change over time in the upper Coosa River Valley, Alabama.

Project Goals for the Current Year

Summarizing from the annual report of the previous year and records of previous EPSCoR meetings, Samford University is required to accomplish the following goals in the current year:

- Complete image analysis for the upper Coosa River basin
- Identify research strategies for articulating and analyzing biology field and remotely sensed data
- Facilitate other institutes to incorporate the remote sensing technology in their research and education
- Develop strategies for incorporating remote sensing into education at the undergraduate and K-levels

Research Accomplishments

Samford University and Dr. Victor Wu (as the P.I. at the university and Co-Director of the Remote Sensing Cluster) are completing various tasks agreed upon in the proposal.

Under the request from Dr. Cline, we agreed to process two TM images and the plant community data collected by Jacksonville State University. We also received ground truth data from JSU to facilitate in image rectification and classification. These undertakings took longer than we had expected due to problems associated with poor data quality. The ground truthing data were recorded in the US Public Land Survey (USPLS, or commonly known as Range & Township) system. With no proper software to process USPLS readings, two lab assistants painstakingly went through hundreds of topographic maps to double-check and convert the data. In the end of December, Dr. Wu completed image classification on from a Landsat TM (20/36, 1996) image and produced a land cover map. This TM scene, transferred from JSU, however, covered only a small portion of our study area. An adjacent scene is needed to complete the coverage. Dr. Cline has been informed about this problem. Samford did not ask for funds to purchase imagery in the Year 5 budget, and do not have the money to remedy the problem. Results from this classification would provide needed information for investigating the extent of human development and landscape changes in the study area. The plant community data were also reorganized and made into a digital database. A copy of which was sent to JSU for analysis in line with biological research.

Dr. Nicholas Kouchoukos, a research associate in the Center for Urban Affairs, University of Alabama at Birmingham, has joint in Dr. Wu's investigation of urban sprawl in the Birmingham Area. Dr. Kouchoukos whose dissertation work involves remote sensing to study agricultural patterns and archeological sites in the Middle East, has brought in significant expertise in this project. A manuscript reporting the preliminary results from this investigation is expected to submit to a related journal this summer.

Publications Accepted and Papers Given

George Cline, Jason Adams, Steve Threlkeld, David Whetstone, Frank Romano, and Victor Wu, Comparison Of Upland Tree Communities On Fort McClellan, Al. to be presented in Alabama Academy of Science, Athens State University, Athens, Al. March 25.

Dr. Victor Wu gave a presentation on new geographic technologies such as GIS and remote sensing and their applications in K-12 level education in a Geographic Awareness Week Teachers' Workshop, held at Samford University, Birmingham, AL. Oct. 24.

Dr. Victor Wu gave a presentation "A Problem-Based Learning Curriculum for Mapping Sciences" in the American Congress of Mapping and Surveying 1999 annual meeting and exhibit in Portland, Oregon on March 17, 1999.

No paper has been published.

Collaborative Activity Within the Cluster

Dr. Wu is working with Dr. George Cline and Dr. Frank Romano of Jacksonville State University to compare the spectral characteristics resulted from image analysis with results from field work on ecological systems.

An investigation of application of remote sensing to identification of areas infested by kudzu in Alabama is under development by Dr. Wu and Dr. Cline.

Student Involvement

In the past year, we have made progresses in both student recruitment and equipment upgrade. Teresa Young, a graduate from University of Alabama with a degree in information science joined in the program to learn GIS and remote sensing. She was also recruited into the ESPCoR project. During regular semesters she was a great help in administering our computer systems. In Summer 1998 she worked part time with Dr. Wu to process data and analyze images. Also participated in the project was the other geography student Bill Maudlin. Having gained valuable experience from the project, both Young and Maudlin moved on to a full time position in Jefferson County, and an internship at Alabama Power Company respectively.

The department also acquired new equipment to strengthen our capacity in teaching and researching in remote sensing. Thanks to an endowment fund from the Alabama Power Company, we purchased in the Fall an LCD projector, which enables us to display video and audio in public presentations. To complement this acquisition, funds were reallocated from the project's Year 4 budget to acquire a laptop computer with multimedia capabilities. Also acquired in the Fall is a high-resolution color scanner, which allow the instructors and students to scan aerial photographs and other images. This acquisition was made possible again thanks to the generous endowment from the Alabama Power Company.

Collaborative Efforts with Business and Other Agencies

We have maintained contacts with the other government agencies and the corporate community. Our efforts to promote remote sensing technology and research are made in a variety of ways.

Dr. Wu was invited to teach a pre-term course "Geographic Information System and Its Marine Research Applications" at the Dauphine Island Sea Lab (DISL) in June for a second time. DISL is a research consortium on marine sciences funded by the State of Alabama. DISL and Dr. Wu agreed to expand the course into a two-week course this summer.

In October, the department hosted a Geography Awareness Week Teachers' workshop. A total of 28 K-12 social science teachers attended the workshop. Dr. Wu lead a session

on geographic technologies and showed participants local satellite images acquired through the EPSCoR project.

Success in Winning Other Research Funds

In December 1998, Dr. Wu was awarded for a two-year \$1,700 Faculty Development Grant to investigate learning issues related to remotely sensed imagery. Dr. Wu has started to prepare for two cognitive experiments to be conducted in Fall 1999. These two experiments are designed to tackle two questions: 1) Are there identifiable patterns in the relationships between a student's academic background and one's performance in image interpretation? 2) How do graphic components such as coloring and scale affect one's performance in image interpretation?

Dr. Wu received from Samford University another grant to develop a Physical Geography course based on Problem-Based Learning (PBL). PBL is an educational approach that stresses on real-world problem solving. It is a great opportunity to incorporate remotely sensing into the course to demonstrate the applications of remote sensing in studying our physical geographic systems. During 1998, Dr. Wu also served as an Associate Facilitator to a Problem-Base Learning (PBL) project lead by Dr. Eric Fournier. Dr. Wu provided essential consultation on technology issues to develop a PBL course on World Regional Geography. The course was taught in Fall 1998 with favorable reviews.

Conclusion

Samford University has or is in the process of completing all of its goals for the past year of the Alabama NASA EPSCoR Grant. Our chief contribution continues to be a support facility as outlined in the original grant, and we have consistently made our facilities available for consortium members. Samford University remains committed to successful completion of the project.

Sincerely,



C. Victor Wu, Co-PI, Remote Sensing Cluster

Cc: Lavern Farmer, Director/Samford University Foundation
Mrs. Mary Howell, Samford University Foundation
Dr. Joe Lewis, Associate Provost
Dr. George Cline, Jacksonville State University

APPENDIX C:

PUBLICATIONS, PRESENTATIONS , GRANTS, AND PATENTS

ADVANCED MATERIALS CLUSTER

APPENDIX C:

PUBLICATIONS, PRESENTATIONS, GRANTS, AND PATENTS ADVANCED MATERIALS CLUSTER

A. Publications

- Alexandrescu, R., A. Crunteanu, R. Cireasca, I. Morjan, and Ashok Kumar "Carbon Nitride Thin Film Synthesized from the Gas-Phase by Laser-Induced Reactions: A Parametric Study, TMS Proceeding Hard Coatings Based on Borides, Carbides, and Nitrides: Synthesis, Characterization, and Applications, Editors: Ashok Kumar, Y. Chung, and Ray W.J. Chia, 73 (1998).
- Catledge, Shane A., and Yogesh K. Vohra, "High density Plasma Processing of Nanostructured Diamond Films on Metals," *J. Appl. Phys.* 84, 6469 (1998).
- Catledge, Shane A., Walt Comer, and Yogesh K. Vohra, "In-situ Diagnostics of Film Thickness and Surface Roughness of Diamond Films on Ti-6Al-4V Alloy by Optical Pyrometry, *Appl. Phys. Lett.* 73, 181 (1998).
- Catledge, Shane A., and Yogesh K. Vohra, "Mechanical properties and Quality of Diamond Films Synthesized on Ti-6Al-4V Alloy Using the Microwave Plasma of CH₄/O₂/H₂ and CO/H₂ Systems," *J. Appl. Phys.* 83, 198 (1998).
- Catledge, Shane A., and Yogesh K. Vohra, "Nitrogen-Induced Nanocrystallinity of CVD Diamond Films on Ti-6Al-4V Alloys, Mat. Res. Soc. Symp.Proc., 1998.
- George, M. A., P. Nag, J. J. Weimer, J. C. Gregory, H. Chen, K.-T. Chen, and A. Burger, "Passivation of ZnCdTe Surfaces by Oxidation in Low Energy Atomic Oxygen", *Journal of Vacuum Science and Technology, A*, 17, 1 (1999).
- George, M.A., J. J. Weimer, and Ashok Kumar "Characterization of Titanium Films Produced by Physical Vapor Deposition Techniques" TMS *Proceeding Hard Coatings Based on Borides, Carbides, and Nitrides: Synthesis, Characterization and Applications*, Editors: Ashok Kumar, Y. Chung, and Ray W. J. Chia, 203 (1998).
- Kapat, J. S., Z. Wei, and Ashok Kumar, "Role of Kinetics of Transformation in Pulsed Laser Ablation" *Applied Surface Science*, 127-129, 212-217 (1998).
- Kumar, Ashok, H.L. Chan, and Y. Vohra, "Characterization of Pulsed Laser Deposited Diamond-like Carbon Films" *Surface Coatings & Technology*, 102, 113-118 (1998).

- Kumar, Ashok, H.L. Chan, and J.S. Kapat "Deposition and Characterization of Titanium Carbide Coatings Using Laser Ablation Method" *Applied Surface Science*, **127-129**, 549-552 (1998).
- Kumar, Ashok, H.L. Chan, and Mr. Shamsuzzoha "Growth and Characterization of Crystalline Metal Nitrides Coatings Prepared by Pulsed Laser Deposition Method" TMS Proceeding *Hard Coatings Based on Borides, Carbides, and Nitrides: Synthesis, Characterization and Applications*, Editors: Ashok Kumar, Y. Chung, and Ray W.J. Chia, **219** (1998).
- Kumar, Ashok, R. Alexandrescu, M.A. George "Deposition and Characterization of Carbon Nitride Films by Laser Processed Methods," MRS Symposium Proceedings *Advances in Laser Ablation of Materials*, **526**, 367-372 (1998).
- Prettyman, T. H., M. A. Hoffbauer, J. Rennie, S. Cook, J. C. Gregory, M. A. George, P. N. Like, M. Amman, S. Solder, and J. Earnhart, "Performance of CdZnTe Detectors Passivated with Energetic Oxygen Atoms", *Nuclear Instruments and Methods in Physics Research, A*, (1999).
- Shamsuzzoha, M. and Ashok Kumar, "A TEM Study of Epitaxial (100) TiC Film Grown on Si(100) Substrates by Pulsed Laser Deposition Method, TMS Proceeding *Hard Coatings Based on Borides, Carbides, Nitrides, Synthesis, Characterization, and Applications*, Editors: Ashok Kumar, Y. Chung, and Ray W. J. Chia, **249** (1998).
- Vengopalan, R., M. A. George, L. C. Lucas, and J. J. Weimer, "The Effect of Nitrogen Diffusion Hardening on the Surface Topography and Electrochemistry of Ti-6Al-4V Alloy", *Proceedings Biomedical Conference* (1998).
- Vengopalan, R., M. A. George, J. J. Weimer, L. C. Lucas, "Spectroscopic and Morphological Evaluation of Nitrogen Diffusion Hardened Ti- 6Al-4V Alloy", *Proceedings Biomedical Conference* (1998).
- Vijayalakshmi, S., M. A. George, J. Federici, M. Beggens, and H. Grebel, "Growth of Silicon Nanoclusters Using Laser Ablation", *Journal of Applied Physics* (1999).
- Vijayalakshmi, S., M.,A. George, J. Sturmman, H. Grebel, "Pulsed-laser Deposition of Si Nanaoclusters, *Applied Surface Science Proceedings of the 1997 4th International Conference on Laser Ablation*, V. **127-129**, (1998) 378.
- Wei, Z. J.S. Kapat, and Ashok Kumar, "Role of Kinetics in Laser Processing" *Applied Surface Science*, **127-129**, 212-217 (1998).

B. Conference Papers Published (refereed)

Catledge, Shane A., and Yogesh K. Vohra, "Nitrogen-Induced Nanocrystallinity of CVD Diamond Films on Ti-6Al-4V Alloys," Proceedings of Materials Research Society, Fall 98.

Catledge, Shane A. and Yogesh K. Vohra, "Structure and Stress Evaluation of Diamond Films Deposited on Ti-6Al-4V Alloy at Low Temperature Using CH₄/O₂/H₂ and Co/H₂ Gas Mixtures," *Mat. Res. Soc. Symp. Proc.* Vol. 505, 629 (1998).

C. Accepted for Publication:

Catledge, Shane A., and Yogesh K. Vohra, "Effect of Nitrogen Addition on the Microstructure and Mechanical Properties of Diamond Films Grown Using a High Density Plasma," *Appl. Phys. Lett.*, (1999), in press.

Chein, T.H., and Y. Tzeng, "Deposition of Diamond by Microwave Plasma in Acetone/Oxygen and Acetone/ Carbon Dioxide Mixtures," Presented in the 6th International Conference on New Diamond Science and Technology, August 30, 1998, South Africa, and *Diamond and Related Materials Journal*, in press (1999).

Chein, T.H., J. Wei, and Y. Tzeng, "Microwave Plasma Enhanced Deposition of Diamond at Elevated Substrate Temperatures," Presented in the 6th International Conference on New Diamond Science and Technology, August 30, 1998, South Africa, and accepted for publication in the *Diamond and Related Materials Journal*, 1999.

Kumar, Ashok "Pulsed Laser Deposition of Superhard Nitride Coatings," Surface Modification Technologies XII, Edited by T.S. Sudarshan, K.A. Khor, and M. Jeandin, in press.

Kumar, Ashok, H.L. Chan, and Rodica Alexandrescu "Pulsed Laser Deposition of Carbides and Nitrides Coatings" International Symposium Proceeding World Ceramic Congress and Forum on New Materials (1998) in press.

Kumar, Ashok and Q. You, "The effects of template layer of AlN on HFCVD Diamond Nucleation" International Symposium Proceeding World Ceramic Congress and Forum on New Materials (1998) in press.

Landsberg, G.B., J.S. Kapat, Ashok Kumar, and I. Ahmed "Simulation of Diamond Film Deposition on Si Substrate using HFCVD Process" *Thin Solid Films* (in press).

Luo, J-G., and V. L. Acoff, "Gamma Titanium Aluminide Developed by Interdiffusion of Multi-Laminated Titanium and Aluminum", *Gamma Titanium Aluminides*, TMS, 1999, (in press).

Tzeng, Y. and H. B. Zhu, "Electron Assisted Deposition of Cubic Boron Nitride by RF Magnetron Sputtering," Presented in the 6th International Conference on New Diamond Science and Technology, August 30, 1998, South Africa, and accepted for publication in the *Diamond and Related Materials Journal*, 1999.

D. Submitted:

E. Presentations:

Bahl, R. Ashok Kumar, and M. Shamsuzzoha "Synthesis of Pulsed Laser Deposited Gallium Nitride Films on Sapphire Substrates," MRS Fall Meeting *Film Growth and Processing Using Hyperthermal Beams* 1998.

Catledge, Shane A., and Yogesh K. Vohra, "Mechanical and Tribological Properties of Nano-structured Diamond Films on Ti-6Al-4V Substrates" Transactions of Metallurgical Society (TMS) meeting (February 28 - March 4, 1999), Symposium on Surface Engineering: Science and Technology I, 1999.

Chan, H.L., Q. You, and Ashok Kumar "Laser Processing of Superhard Coatings," The University of South Alabama 3rd Annual Research Forum 1998.

Chan, H.L., P. Davis, A. Mangiaracina, Ashok Kumar, G. Wattuhewa, J.A. Barnard, and J.J. Weimer "Investigations of Structural and Mechanical Properties of Carbide and Nitride Coatings Prepared by Laser Ablation Method," *Tenth Annual Alabama Materials Research Conference*, Auburn 1998.

Galleev, M., Ashok Kumar, I. Ahmed "Synthesis and Characterizations of Diamond Films Grown by Filament Assisted CVD Methods," 17th Annual Meeting of the Alabama Imaging and Microscopy Society, Orange Beach, AL 1998.

Kumar, Ashok, and R. Bahl "Growth, Structure, and Mechanical Properties of Pulsed Laser Deposited Microlaminates Coatings," MRS Fall Meeting *Polycrystalline Thin Films - Processing Structure-Property Relationship* 1998.

Kumar, Ashok, M. Galeev, and M. Shamsuzzoha "Effects of Pretreated Substrates on the Growth Morphology of Diamond Films Prepared by Hot Filament Chemical Vapor Deposition Method," *MRS Fall Meeting Properties and Processing of Vapor-Deposited Coatings* 1998.

Kumar, A., Pulsed laser deposition of transition metal of carbides and nitrides coatings, *Invited Talk*, Ninth Cimtec- World Ceramic Congress & Forum on New Materials, 14th-19th June, Florence, Italy (1998)

- Kumar, A., The synthesis, characterization and mechanical properties of carbides and nitrides films prepared by pulsed laser deposition method, *Invited Talk*, Romopto 97, Bucharest (Romania), 1998.
- Sanderson, L.A.W., M. A. George, and J.J. Weimer, "Observations of Surface Potentials via Atomic Force Microscopy", *American Vacuum Society Meeting*, November, 1998, Baltimore, MD.
- Sanderson, L.A.W., J.J. Weimer, H.L. Chan, and Ashok Kumar "Surface Characterization of Thin Film Hard Coating," *Tenth Annual Alabama Materials Research Conference*, Auburn 1998.
- Shen, F., Y. Zhang, S. Vijayalakshmi, M. A. George, and H. Grebel, Characterization of Laser Ablated Germanium Nanoclusters", *Materials Research Society Meeting*, November, 1998, Boston, MA.
- Tzeng, Y., "Methanol-based Microwave Plasma Enhanced Diamond Deposition Process," to be presented in the ADC/FCT '99, August 31, 1999, Japan.
- Tzeng, Y., "Methanol-based Hot-filament Assisted Diamond Deposition Process," to be presented in the ADC/FCT '99, August 31, 1999, Japan.
- Zhu, Shen, Ching-Hua Su, S. Lehoczky, and M. A. George, "Orientation Effects in ZnO Films Using Off-Axis Sputtering Deposition", *The Fifth IUMRS International Conference on Advanced Materials, Symposium W: Material Synthesis and Modification by Energetic Beams*, June 1999.

F. Patents

- George, Michael, "A Silicon Carbide Based Elevated Temperature Methane Detector", US Patent Disclosure, 1998.
- Kumar, Ashok, and M. Galeev "Diamond Growth on Si Nanoparticles Embedded in Silicon Substrates" (under preparation).
- Tzeng, Y., "Methanol-based Microwave Plasma Enhanced Diamond Deposition Process", US Provisional Patent Application filed February, 1999.
- Tzeng, Y., "Methanol-based Hot-filament Assisted Diamond Deposition Process", US Provisional Patent Application filed in February, 1999.
- Vohra, Y. K., and S. A. Catledge, "A Process for Ultra Smooth Diamond Coating on Metals", D6176, US Patent Application filed in October, 1998,

G. Grants and Proposals

- George, M. A. (PI), "Production of Stable Elevated Temperature SiC Sensors" to NASA, (\$75K) (Renewal, FY98-99), funded.
- George, M. A. (PI), "Characterization of Nitrogen Hardened Ti-alloys for Orthopedic Applications" to NSF (\$15K), funded.
- George, M. A. (PI), "NSF Site Program for Research Experiences for Undergraduates in Materials Science: Study of Advanced Materials Using State-of-the-Art Instrumentation" to NSF (\$210K), pending.
- George, M. A. (PI), "Investigation of Resonating Microcantilevers for sensor Applications", to NSF (\$360K), pending.
- George, M. A. (Co-I), "Alabama Distributed User Center for Surface and Interface Processing and Characterization" to NSF (\$180K), pending.
- George, M. A. (PI), "Study of Relative Contribution of Gravity-driven Fluid Flows in the Vapor Phase Growth of Silicon Carbide Crystals" to NASA (\$450K), pending.
- Kumar, A. (PI), "Novel Synthesis and Fabrication of Hybrid Nanostructured Coatings for Manufacturing Applications", to NSF (\$213,362), pending.
- Kumar, A. (PI), "Growth and Characterization of Carbides/Nitrides Thin Films Prepared by Laser Processed Methods", to National Research Council (renewal, \$13K), funded.
- Tzeng, Y. (PI), "Plasma and Laser Assisted Manufacturing Technologies", to Alabama Microelectronics Science and Technology Center (\$40K), funded.
- Tzeng, Y. (PI), "Wide-bandgap Semiconductro Coatings for Cold Cathode Applications", to US Navy (\$390K), funded.
- Vohra, Yogesh K., (PI), "Synthetic Diamond Encapsulation of Microprobes for Novel High Pressure Experiments", to Lawrence Livermore National Laboratory (LLNL), (renewal, \$26.8K), funded.
- Vohra, Yogesh K., (PI), "Phase Transformations in Rare Earth Metals and Alloys Subjected to Ultra High Pressures and Synthetic Diamond Anvils", to NSF (renewal, \$86.9K), funded.
- Vohra, Yogesh K., (PI), "Regional Initiative to Promote Undergraduate Participation in Experimental and Computational Materials Research", to NSF, (renewal \$53.5K), funded.

Vohra, Yogesh K., (PI), "Evaluation of Nano-diamond Coated Titanium Alloys", to NASA-Alabama Space Grant Consortium (\$9.9K), funded.

H. PhD Dissertations and MS Theses

Bahl, R., Masters thesis entitled "Evaluation of Mechanical Properties of Superhard Coatings", University of South Alabama, 1999.

Catledge, Shane A., Ph.D. dissertation entitled "Synthesis of Diamond Thin Films on Ti-6Al-4V Alloy: Residual Stress and Mechanical Properties". The University of Alabama at Birmingham, 1999.

Galeev, Michael, Masters thesis entitled "Diamond Film Growth on Structural Substrates for Cutting Tool Applications", University of South Alabama, 1999.

Geng, Yibing, Masters thesis entitled "Fabrication and Device Implementation of Laser Processed Ferroelectric Thin Film", University of South Alabama, 1999.

Israel, Andrew, Masters thesis entitled "A Detailed Investigation Of Microwave Plasma-Assisted Chemical Vapor Deposition Growth Parameters", The University of Alabama at Birmingham", 1998.

Padungak, U., Masters thesis entitled "Numerical Simulation of Diamond Deposition by Combustional Flame Assisted CVD Process", University of South Alabama, 1999.

Wei, Z., Masters thesis entitled "Numerical Simulation of Pulsed Laser Ablation Deposition Process", University of South Alabama, 1999.

APPENDIX D:

**PUBLICATIONS, PRESENTATIONS,
AND GRANTS**

REMOTE SENSING CLUSTER

**APPENDIX D:
Publications, Presentations and Grants
Remote Sensing Cluster**

A. Publications (in press)

Hung, C.-C., A. Fahsi, and T. L. Coleman. 1999. Image classification. *In* J. G. Webster (ed.). Wiley Encyclopedia of Electrical and Electronics Engineering. John Wiley and Sons Publisher, New York, NY. (In Press)

Manu A., T. L. Thurow, A. S. R. Juo, and I. Zanguina. 1999. Integrated watershed management. *Journal of Soil and Water Conservation*. (In Press)

B. Submitted

Boggs, J., T. D. Tesgaye, A. Fahsi, and C. Reddy. 1998. Relationship between cotton leaf nitrogen and soil nitrate content under poultry litter plots. *Remote Sensing of Environment*. (Submitted February, 1998)

Fahsi, A., T. D. Tsegaye, T. L. Coleman, and W. Tadesse. 1998. Incorporation of DEM ancillary data with Landsat-TM data to improve landcover classification accuracy. *Elsevier's Forest Ecology and Management Journal*. (Submitted July 1998)

Rajbhandari, N. B., J. D. Gregory, C. Franklin, and J. E. Parsons. 1999. Effects of flow dispersal in forested filter zones. *Journal of the American Water Resources Association*. (Submitted November 1998)

Rajbhandari, N. B., J. D. Gregory, C. Franklin, and J. E. Parsons. 1999. Effectiveness of small- forested filter zones on sediment and nutrient deposition of dispersed agricultural runoff. *Journal of Soil and Water Conservation*. (Submitted January 1999).

C. Publications or Presentations at Meetings:

Cline, George, Jason Adams, Steve Threlked, David Whetstone, Frank Romano, and Victor Wu, "Comparison of Upland Tree Communities on Fort McClellan, AL., Alabama Academy of Science, March 25, 1999, Athens State University, Athens, AL.

Fahsi, A., J. Boggs, T. Tsegaye, W. Tadesse, and T. L. Coleman. Precision Agriculture with Hyperspectral remotely sensed data, GIS, and GPS technology: a Step Toward an Environmentally Responsible Farming. *In Earth Surface Remote Sensing*. G. Cecchi, E. T. Engman, and E. Zilioli, Editors. *Proceedings of the SPIE*. Vol. 3499:270-276, 1998.

Hung, C. C., A. Fahsi, and T. L. Coleman. Integration of Digital Elevation Models and Contextual Information to Improve Image Classification Accuracy. p. 83. *Proceedings of the 22nd CAPASUS Annual Conference*. 3-5 July 1998, Atlanta, GA.

Jandebeur, Tom, Mandy Cooper, and Pat Smith, "Application of Remote Sensing Technology to Locate Cedar Glade Habitat in North Alabama: A Preliminary Report." Paper presented before the Geography, Forestry, Conservation, and Planning section of the Alabama Academy of Science at its 76th Annual Meeting, March 24-27, 1999, Athens State University, Athens, AL.

Rajbhandari, N. B, W. Tadesse, A. Fahsi, T. L. Coleman, and G. F. Brown. 1999. Use of Landsat Thematic Mapper and Geographic Information System for stream-flow analysis. *Proceedings of the ACSM-ASPRS Annual Convention and Exhibition*, 17-21 May 1999, Portland, OR. (In Press)

Wu, Victor, "GIS and Remote Sensing and their Applications in K-12 Level Education," Geographic Awareness Week Teachers' Workshop, October 24, 1998, Samford University, Birmingham, AL.

Wu, Victor, "A Problem-Based Learning Curriculum for Mapping Sciences," American Congress of Mapping and Surveying 1999 Annual Meeting, March 17, 1999, Portland, Oregon.

D. Proposals

Woods, Charles, C. 1998. The College Fund/Second Nature, Building Environmental Stewardship (BES). \$50,000.00.

Coleman, T. (PI), G. DaBai, and A. Fahsi, "Minority Faculty GIS/RS Applications Workshop", to USDOL, (\$5K), pending.

Fahsi, A. (PI), T. Tsegaye, T. Coleman, A. Manu, and C. Martin, "Watershed Hydrology as Predicted by Site-Specific Soil Properties, Vegetation Parameters, and Meteorological Inputs Using a Remote Sensing/GIS Approach", to NASA (\$593.4K), pending.

Rajbhandari, N. (PI), T. Coleman, and A. Fahsi, T. Tsegaye, "Development of Overland Flow Roughness Coefficient for Forested Watersheds Using the Airborne Visible-Infrared Imaging Spectrometer Data", to NASA (\$430K), pending.

Tsegaye, T. (PI), T. Coleman, R. Taylor, G. Sharma, "Providing Research Services in the Area of Army Land and Natural Resources Impact Assessment: Ecosystem and Simulation Modeling", to US Army (\$6000K), pending.

Coleman, T. (PI), T. Tsegaye, A. Fahsi, and N. Rajbhandari, "National Imagery and Mapping Agency: GIS and Remote Sensing Curriculum Enhancement at Alabama A&M University", to USDoI (\$107.2K), pending.

Manu, A. (PI), C. Beyl, and C. Reddy, "Higher Education Multicultural Scholars Program: Enhancement of Minority Participation in Plant Enhancement of Minority Participation in Plant", to USDA (\$100K), pending.

Sistani, K. (PI), D. Mays, and A. Fahsi, "Capacity Building Grants: Environmental Impact of Land Applied Animal Waste: Biogeochemistry and Using Remote Sensing and GIS," to USDA (\$218K), pending.

Rajbhandari, N. (PI), A. Fahsi, and P. Cannon, "Alabama Clean Water ACT Section 319(h): Identification of Critical Streams in the Flint River Watershed Using a Non-Point Source Model Geographic Information System (GIS) and Remote Sensing", to ADEM (\$125.3K), pending.